Abbreviation	Meaning
AEG	General Railway Law
AFP	Agricultural Investment Support Programme
ArbStättR	Workplace Guidelines
ArbStättV	Workplace Regulations
BauGB	Building Law
BGB	German Civil Code
BGR	Association of Commercial Accident Insurance Companies
BImSchG	Federal Prevention of Emissions Law
BOStrab	Construction and Operation of Trams Regulation
BS(I)	British Standards (Institute)
CEN	Committee for European Normalisation
CHP	combined heat and power
CIE	International Lighting Commission
CPM	Critical Path Method
DB	Deutsche Bahn – German Railways
DEHOGA	German Hotel and Inn Association
DFS	German Air Traffic Control
DiBt	German Institute for Building Technology
DIN	German Institute for Standardisation
DN	normal diameter
EBO	Construction and Operation of Railways Regulation
EEG	Renewable Energy Law
EIA	Environmental Impact Assessment
EN	European (standard)
EnEV	Energy Saving Regulation
FEA	Federal Environment Agency
FEU	40-foot equivalent unit (container)
FFL	finished floor level
FIS	International Ski Federation
FGSV	Research Company for Roads and Traffic
GEFMA	German Facility Management Association
GIF	Company for Property Industry Research
GUV	Guidelines of the German Association of Accident Insurers (health and safety)
HeizAnlV	Heating Plant Regulation
HGV	heavy goods vehicle
HOAI	Fee Regulations for Architects and Engineers
HWR	auxiliary inverter
ICAO	International Civil Aviation Organisation
ICE	Inter-City Express
IndBauR	Industrial Building Guidelines
ISO	International Standards Organisation
KfW	'Reconstruction' Subsidy Bank
KFZ	vehicle
LBO	state building regulation
LC	liquid crystal
LED	llight emitting diode
LIDC	luminous intensity distribution curve
LiTG	German Technical Light Association
LPZ	lightning protection zone
LU	large animal unit (500 kg live weight)
MBO	model building regulation (basis for LBO)
MPM	Metra Potential Method
MTA	medical/technical assistant
MVZ	outpatient medical centre
ODP	operating department practitioner
ÖPNV	public transport
PKW	passenger car
RAL	German quality assurance mark
RAS-L (-EW/-Q)	Road Construction Guidelines – Road Layout (Drainage / Cross-section)
SchBauR	School Building Guidelines
StLB	Standard Book of Bill Items
StVo	Street Traffic Regulations
SUV	sports utility vehicle
TEU	20-foot equivalent unit (container)
UIC	International Union of Railways
VDE	Association of German Electrical Engineers
VDI	Association of German Engineers
VdS	Loss Prevention (fire and security testing institute)
VkVO	Retail Regulations
VOB	Contract Regulations for Building Works
VStättVO	Places of Assembly Regulations
Wh	withers height (horse)
WSG	Water Protection Law
ZH	Indicates Guidelines of BGR (Association of Commercial Accident Insurance Companies)
ZVEI	Central Association of Electrical and Electronics Industries

Unit, Abbreviation

10^{12}	10 cm 12 mm (superscript number = mm)
″	English inch
′	English foot
H or h	height or high
W or w	width or wide
h	hour
min	minute
s	second
12°	degrees in Celsius (C)
J	joule, energy
N	newton, force
Pa	pascal, pressure
2° 3′ 4″	2 degrees, 3 min, 4 s. 360-degree division
%	per cent, hundredth
‰	per thousand, thousandth
Ø	diameter
/	per (e.g. t/m = tonne per m)

Greek Alphabet

A	α	(a)	Alpha
B	β	(b)	Beta
Γ	γ	(g)	Gamma
Δ	δ	(d)	Delta
E	∊	(e)	Epsilon
Z	ζ	(z)	Zeta
H	η	(e)	Eta
Θ	ϑ	(th)	Theta
I	ι	(i)	Iota
K	κ	(k)	Kappa
Λ	λ	(l)	Lambda
M	μ	(m)	Mu
N	ν	(n)	Nu
Ξ	χ	(x)	Xi
O	o	(o)	Omicron
Π	π	(p)	Pi
P	ρ	(r)	Rho
∑	σ	(s)	Sigma
T	τ	(t)	Tau
Y	υ	(y)	Upsilon
Φ	ϕ	(ph)	Phi
X	ψ	(ch)	Chi
Ψ	ν	(ps)	Psi
Ω	φ	(o)	Omega

Mathematical Symbols

>	greater than
≧	equal or greater than
<	less than
≦	less than or equal
Σ	sum of
<|	angle
sin	sine
cos	cosine
tan	tangent
ctg	cotangent
=	equal
≠	not equal
~	approximately
∞	infinity
‖	parallel
×	times, multiplied by
/	divided by
⊥	right-angled
v	volume
ω	solid angle
√	square root of
≅	congruent
Δ	triangle
↑↑	same direction, parallel
↑↓	opposite directions, parallel

Roman Numbers

I =	1
II =	2
III =	3
IV =	4
V =	5
VI =	6
VII =	7
VIII =	8
IX =	9
X =	10
XV =	15
C =	100
CL =	150
CC =	200
CCC =	300
CD =	400
D =	500
DC =	600
DCC =	700
DCCC =	800
CM =	900
M =	1000
MCMLX =	1960

SI units – Système International d'Unités

The international system of units: the most commonly used system of measurement and units in science. Basic units, which are not derived from any other.

Quantity	Basic unit name	Symbol	Definition based on	SI units included in definition
1 length	metre	m	wavelength of krypton radiation	–
2 mass	kilogram	kg	international prototype	–
3 time	second	s	period of caesium radiation	–
4 electrical current	ampere	A	electrodynamic force between two conductors	kg, m, s
5 temperature (thermodynamic temperature)	kelvin	K	triple point of water	–
6 luminous intensity	candela	cd	radiation from freezing platinum	kg, s
7 amount of substance	mole	mol	molecular mass	kg

1 Basic SI units

Symbol	Unit	Description
a) Thermal insulation		
t	(°C, K)	temperature
t	(K)	temperature difference
q	(Wh)	quantity of heat
λ	(W/mK)	thermal conductivity
λ'	(W/mK)	equivalent thermal conductivity
Λ	(W/m²K)	coefficient of thermal transmittance
α	(W/m²K)	coefficient of thermal transmission
U	(W/m²K)	coefficient of thermal transmittance
$1/\Lambda$	(m²K/W)	thermal insulation value
$1/\alpha$	(m²K/W)	thermal transmission resistance
1/k	(m²K/W)	thermal transmittance resistance, 1/U
D′	(m²K/W × cm)	thermal resistance per cm
c	(Wh/kgK)	specific thermal capacity
S	(Wh/m³K)	volumetric specific heat
β	(1/K)	coefficient of thermal expansion
a	(mK)	distance coefficient
P	(Pa)	pressure
P_o	(Pa)	(partial) vapour pressure
g_o	(g)	vapour quantity
g_k	(g)	condensed water quantity
v	(%)	relative air humidity
μ	(–)	diffusion resistance coefficient
$\mu \times d$	(cm)	diffusion-equivalent air layer
Λ_o	(g/m²hPa)	water vapour resistance factor
$1/\Lambda_o$	(m²hPa/g)	diffusion resistance
$\mu\lambda$	(W/mK)	layer factor
$\mu\lambda'$	(W/mK)	layer factor of air layers
P	(€/kWh)	cost of heat
b) Sound insulation		
λ	(m)	wavelength
f	(Hz)	frequency
f_{gr}	(Hz)	limit frequency
f_η	(Hz)	resonance frequency
E_{dva}	(N/cm²)	dynamic elasticity modulus
S′	(N/cm³)	dynamic stiffness
R	(dB)	sound reduction CONTENTS (airborne sound) in laboratory
R_m	(dB)	median airborne sound reduction
R′	(dB)	sound reduction CONTENTS with flanking transmission (airborne sound)
LSM	(dB)	airborne sound insulation margin
L_n	(dB)	impact sound pressure level
V/M	(dB)	sound improvement due to one floor or ceiling layer
TSM	(dB)	impact sound reduction
a	(–)	degree of sound absorption
A	(m²)	equivalent sound-absorbing area
r	(m)	resonance radius
L	(dB)	sound level reduction

2 Physical symbols in the SI system

Prefixes and their Abbreviations are:					
T (tera-)	= 10^{12}	(million million)	c (centi-)	= 1/100	hundredth
G (giga-)	= 10^{9}	(thousand million)	m (milli-)	= 10^{-3}	thousandth
M (mega-)	= 10^{6}	(million)	µ (micro-)	= 10^{-6}	millionth
k (kilo-)	= 10^{3}	(thousand)	n (nano-)	= 10^{-12}	
h (hekto-)	= 100	(hundred)	p (pico-)	= 10^{-12}	
da (deca-)	= 10	(ten)	f (femto-)	= 10^{-15}	
d (deci-)	= 1/10	(tenth)	a (atto-)	= 10^{-18}	
only one prefix may be used to describe a decimal multiple					

3 Decimal multipliers and dividers of units

Quantity to be measured		Unit in the SI system, compulsory from 1978	Conversion factor
length	m	metre	
area	m²	square metre	
volume	m³	cubic metre	
mass	kg	kilogram	
force	N	newton = 1 kg m/s²	9.8
pressure	Pa	pascal = 1 N/m²	133.3
	bar	bar = 100,000 Pa Pa = 100,000 N/m	0.98
temperature	°C K	degree Centigrade kelvin*	1 10
work (energy, heat quantity)	Ws, J, Nm	watt second = joule = newton metre	4186
	Wh	watt hour = 3.6 KJ	1.163
	kWh	kilowatt hour = 10³ Wh = 3.6 MJ	1.163
power (energy transfer, heat transfer)	W W	watt watt	736 1.163
*compulsory from 1975			

4 Conversion of basic units

$1\ m \times m = 1\ m^2$ $\quad$ $1\ m \times 1\ s^{-1} = 1\ m\ s^{-1}$ (= 1 m/s)
$1\ m \times 1\ s^{-2} = 1\ ms^{-2}$ (= 1 m/s²)
$1\ kg \times 1\ m \times 1\ s^{-2} = 1\ kg\ m\ s^{-2}$ (= 1 kg m/s⁻²)
$1\ kg \times 1\ m^{-3} = 1\ kg\ m^{-3}$ (= 1 kg/m³)
$1\ m \times 1\ m \times 1\ s^{-1} = 1\ m^2 s^{-1}$ (= 1 m²/s)

5 Examples of 'derived SI units' through combining basic units

coulomb	1 C	= 1 As	ohm	1 Ω	= 1 V/A
farad	1 F	= 1 As/V	pascal	1 Pa	= N/m²
henry	1 H	= 1 Vs/A	siemens	1 S	= 1/Ω
hertz	1 Hz	= 1 s⁻¹ = (1/s)	tesla	1 T	= 1 Wb/m²
joule	1 J	= 1 Nm = 1 Ws	volt	1 V	= 1 W/A
lumen	1 lm	= 1 cd sr	watt	1 W	= 1 J/s
lux	1 lx	= 1 lm/m²	weber	1 Wb	= 1 Vs
newton	1 N	= 1 kg m/s²			

For apparent electrical power, the watt may be described as volt ampere (VA), idle electrical power as Var (ver).

6 Names and symbols for derived SI units

1 N 2 1 s 2 1 m² = 1 Nsm² $\quad$ 1 A2 1 s = 1 As = 1 C
1 rad 2 1 s² = 1 rad s¹ (= 1 rad/s) $\quad$ 1 As/V = 1 C/V = 1 F

7 Examples of SI units derived through combining basic units with named derived units

thermal resistance	$1/\Lambda$ = 1 m²h K/kcal	= 0.8598 m²K/W
thermal conductivity	λ = 1 kcal/m h K	= 1.163 W/m K
coefficient of thermal transmittance	U = 1 kcal/m² h K	= 1.163 W/m²K
coefficient of thermal transmission	α = 1 kcal/m²h K	= 1.163 W/m²K
bulk density	= 1 kg/m³	= 1 kg/m³
calculation weight	= 1 kp/m³	= 0.01 kN/m³
compressive strength	= 1 kp/cm²	= 0.1 N/mm²

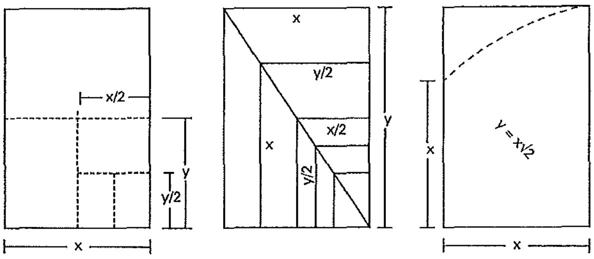
8 Conversion of table values to new units

Units of measurement in building

The international system of measurement with SI units has been valid since 1 January 1978.

Measurement	Symbol	SI unit		Statutory unit		Old unit		Description
		Name	Symbol	Name	Symbol	Name	Symbol	
normal angle	α β γ	radian	rad					1 rad = 1 m/m = 57.296° = 63.662 gon
				round angle	pla			1 pla = 2 π rad
						right angle	L	1^L = ¼ pla = (π/2) rad
				degree	°			1° = 1^L/90 = 1 pla/360 = π/180 rad
				minute	8			18 = 1°/60
				second	(			1(= 18/60 = 1°/3600
				gon or grad	gon	new degree	9	1 gon = 1 g = 1^L/100 = 1 pla/400 = π/200 rad
						new minute	a	1 c = 10^{-2} gon
						new second	cc	1 cc = (10^{-2}) c = 10^{-4} gon
length	l	metre	m	micrometre	μm	inch	in	1 in = 25.4 mm
				millimetre	mm	foot	ft	1 ft = 30.48 cm
				centimetre	cm	fathom	fathom	1 fathom = 1.8288 m
				decimetre	dm	mile	mil	1 mile = 1609.344 m
				kilometre	km	sea mile	sm	1 sm = 1.852 km
area, cross-sectional area, area of plot of land	A, q	square metre	m^2					
				are	a			1 a = 10^2 m^2
				hectare	ha			1 ha = 10^4 m^2
volume	V	cubic metre	m^3					
				litre	l			1 l = 1 dm^3 = 10^{-3} m^3
normal volume	V_n					normal cubic metre	Nm^3	1 Nm^3 = 1 m^3 in normal condition
						cubic metre	cbm	
time, period, duration	t	second	s					
				minute	min			1 min = 60 s
				hour	h			1 h = 60 min = 3600 s
				day	d			1 d = 24 h = 86 400 s
				year	a			1 a = 8765.8 h = 31.557 × 10^6 s
frequency	f	hertz	Hz					1 Hz = 1/s for the expression of frequencies in
duration of a cycle								dimensional equations
angular frequency	φ	reciprocal second	1/s					φ = 2 × f
angular velocity	φ	radians per s	rad/s					φ = 2 × n
speed of revolutions	n	reciprocal second	1/s	revolutions per sec/min	r/s	revs per sec/min	r.p.s.	1/s = t/s = U/s
					r/m		r.p.m	
velocity	v	metre per second	m/s	kilometres per hour	km/h			1 m/s = 3.6 km/h
						knot	kn	1kn = 1sm/h = 1.852 mph
acceleration due to gravity	g	metre per second squared	m/s^2			gal	gal	1 gal = 1 cm/s^2 = 10^{-2} m/s^2
mass:	m	kilogram	kg					
weight (on scales)				gram	g			1 g = 10^{-3} kg
				tonne	t			1 t = 1 Mg = 10^3 kg
						pound	lb	1 lb = 0.45359237 kg
						metric hundredweight	cwt (metric)	1 cwt (metric) = 50 kg
force	F	newton	N					1 N = 1 kg/m/s^2 = 1 Ws/m = 1 J/m
thrust	G					dyne	dyn	1 dyn = 1 g cm/s^2 = 10^{-5} N
						pond	p	1 p = 9.80665 × 10^{-3} N
						kilopond	kp	1 kp = 9.80665 N
						megapond	Mp	1 Mp = 9806.65 N
						kilogram force	kg	1 kg = 9.80665 N
						tonne force	t	1 t = 9806.65 N
mech. stress, strength	σ	newton per square metre	N/m^2	newton per square millimetre	N/mm^2		kp/cm^2	1 kp/cm^2 = 0.0980665 N/mm^2
							kp/mm	1 kp/mm^2 = 9.80665 N/mm^2
work, energy	W,E	joule	J					1 J = 1 Nm = 1 Ws = 10^7 erg
				kilowatt hour	kWh			1 kWh = 3.6 × 10^6 J = 3.6 MJ
						horsepower per hour	h.p./h	1 h.p. = 2.64780 × 10^6 J
						erg	erg	1 erg = 10^{-7} J
heat quantity	Q	joule	J			calorie	cal	1 cal = 4.1888 J = 1.163 × 10^{-3} Wh
torque	M	newton metre	Nm			kilopond metre	kpm	1 kpm = 9.80665 J
bending moment	M_b	or joule	J					
power,	P	watt	W					1 W = 1 J/s = 1 N m/s = 1 kg m^2/s^3
energy current						horsepower	h.p.	1 h.p. = 0.73549675 kW
thermodynamic temperature	T	kelvin	K			degree Kelvin	°K	1°K = 1 K
						degree Rankine		1°R = 5/9 K
Centigrade temperature	ϑ		K	degree Centigrade	°C		°R, °RK	ϑ = $T - T_0$ T_0 = 273.15 K
								Δϑ = ΔT, where:
temperature interval and differential	Δϑ or ΔT				°C	degree	deg	1 K = 1°C = 1 degree to be used in equations
Fahrenheit temperature	ϑ_F					degree Fahrenheit	°F	ϑ_F = 9/5 ϑ + 32 = 9/5 T – 459.67
Reaumur temperature	ϑ_R					degree Reaumur	°R	ϑ_R = 4/5 ϑ, 1°R = 5/4 °C

❶ SI units and statutory units (excerpt applicable to building)



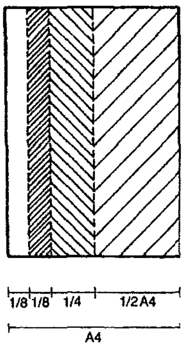
❶–❸ Basis of paper formats

Format	Series A	Series B	Series C
0	841 × 1189	1000 × 1414	917 × 1297
1	594 × 841	707 × 1000	648 × 917
2	420 × 594	500 × 707	485 × 648
3	297 × 420	353 × 500	324 × 458
4	210 × 297	250 × 353	229 × 324
5	148 × 210	176 × 250	162 × 229
6	105 × 148	125 × 176	114 × 162
7	74 × 105	88 × 125	81 × 114
8	52 × 74	62 × 88	57 × 81
9	37 × 52	44 × 62	
10	26 × 37	31 × 44	
11	18 × 26	22 × 31	
12	13 × 18	15 × 22	

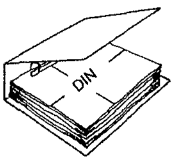
❹ Sheet sizes

Format	Abbreviation	mm
half length A4	½ A4	105 × 297
quarter length A4	¼ A4	52 × 297
eighth length A7	¼ A7	9 × 105
half length C4	½ C4	114 × 324
etc.		

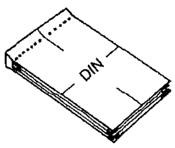
❺ Strip formats



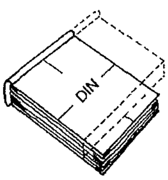
❻ Strip formats in A4



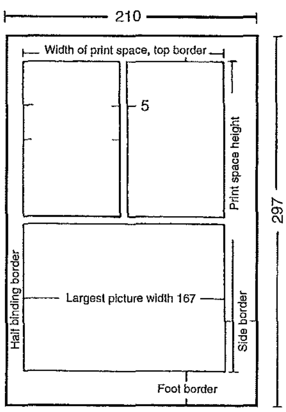
❼ Loose-leaf binder



❽ Pads, carbonless duplicate books



❾ Bound and trimmed books



❿ → ⓫

Standardised formats provide a foundation for office furniture design, which then determines the development of the floor plan. Good knowledge of paper formats is therefore important for the designer.

Paper formats have generally been standardised (apart from in the USA) to conform to the internationally accepted (ISO) series of paper sheet sizes (A,B,C,D). These were developed on the basis of an area of 1 m^2, divided according to the ratio of the sides:

$x : y = \sqrt{2}$ → ❸ length of side x = 0.841 m

$x \times y = 1$ length of side y = 1.189 m

The basic format (a rectangle with an area of 1 m^2 and side lengths as above) forms the basis for all the smaller sizes. The A format series is produced by halving or doubling the basic format → ❶ + ❷. The additional series B and C are intended for items in dependent paper sizes, e.g. envelopes, binders and files → ❹.

The formats in the B series are the geometric mean dimensions of the A series. The formats in the C series are the geometric mean dimensions of the A and B series → ❹.

Strip (or side margin) formats are made by dividing the main formats lengthwise into halves, quarters and eighths (for envelopes, signs, drawings etc.) → ❺ + ❻.

File cards without tabs correspond exactly to the standard formats. Tab cards are larger to allow for the tab, i.e. they have a projection at the upper edge for classification.

Binders, files and folders are wider than the standard format to provide space for the fixing mechanism. Widths should if possible be selected from the possible dimensions from series A, B, C → ❼.

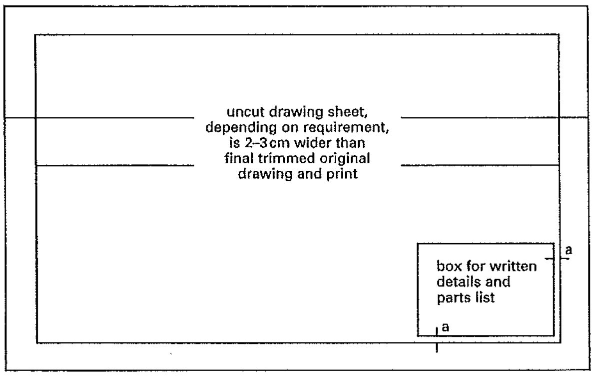
Pads and carbonless duplicate books have precisely the standard formats; if there is a standing perforated edge, then here the sheets are smaller than the standard format → ❽.

Bound and trimmed books have precisely the standard format. If a further trim is necessary during binding, then the pages will be slightly smaller than the standard format, and the cover will project accordingly. The cover size must be at least the standard format → ❾. The cover width is determined by the binding process.

	picas		mm	
type area width	39.5	40.5	167	171
type area height (without header/footer)	58.5	59	247	250
space between columns	1		5	
max. width, double columns	39.5		167	
max. width, single column	19		81	
inside (gutter) margin, nominal			16	14
outer (side) margin, nominal			27	25
top (head) margin, nominal			20	19
bottom (foot) margin, nominal			30	28

⓫ Layouts and type area of the A4 standard format → ❿

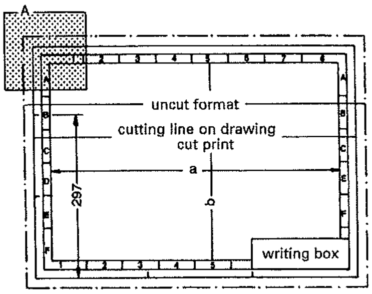
BS EN ISO 128
BS 1192
BS EN ISO 4157
DIN 824



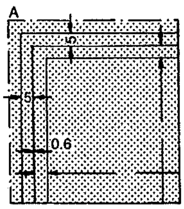
❶ Standardised drawing

Sheet sizes according to ISO series A	ISO A0	ISO A1	ISO A2	ISO A3	ISO A4	ISO A5
Format: untrimmed blank sheet (mm)	880 × 1230	625 × 880	450 × 625	330 × 450	240 × 330	165 × 240
Format: trimmed finished sheet (m)	841 × 1189	594 × 841	420 × 594	297 × 420	210 × 297	148 × 210

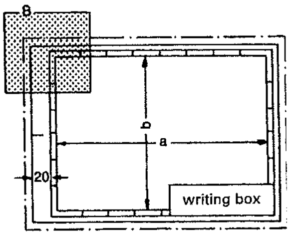
❷ Sheet sizes



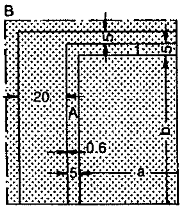
❸ ISO size A2; A1; A0



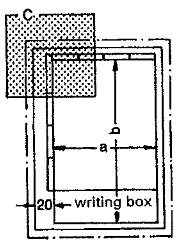
cut-out ISO A2, A1, A0



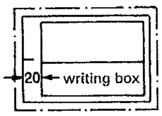
❹ ISO size A3



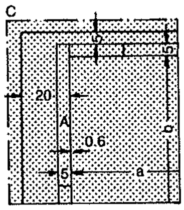
cut-out ISO A3



❺ ISO size A4



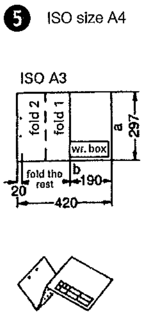
❻ ISO size A5

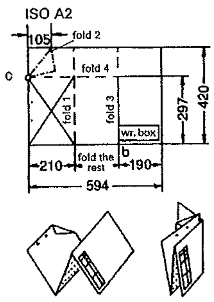


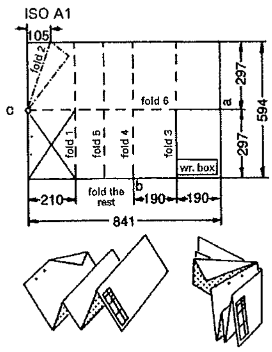
cut-out ISO A4

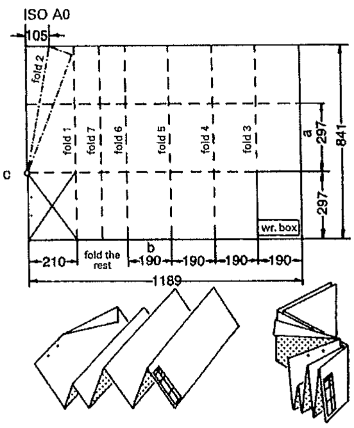
Division for	No. identical fields by sheet size				
	A0	A1	A2	A3	A4
a	16	12	8	8	4
b	12	8	6	6	4

❼ Field divisions (grid squares)









❽ Folding schemes and dimensions

The use of **standard drawing formats** makes it easier for architects to lay out drawings for discussion in the design office or on the building site, and also facilitates posting and filing. The trimmed, original drawing or print must therefore conform to the formats of the ISO A series → ❶, ❸–❻.

The **title block** should be the following distance from the edge of the drawing:
for formats A0–A3 10 mm
for formats A4–A6 5 mm
For small drawings, a filing margin of up to 25 mm can be used, which reduces the usable area of the finished format. As an exception, **narrow formats** can be made by adding together a row of identical or adjacent shapes from the format range.

From normal roll widths, the following sizes can be used to provide formats in the A series:
for drawing paper, tracing paper 1500, 1560 mm
(derived from these: 250, 1250, 660, 900 mm)
for print paper: 650, 900, 1200 mm.
If all the drawing formats up to A0 are to be cut from a paper web, a roll width of at least 900 mm will be necessary.
Drawings which are to be stored in A4 box files should be folded as follows → ❽:

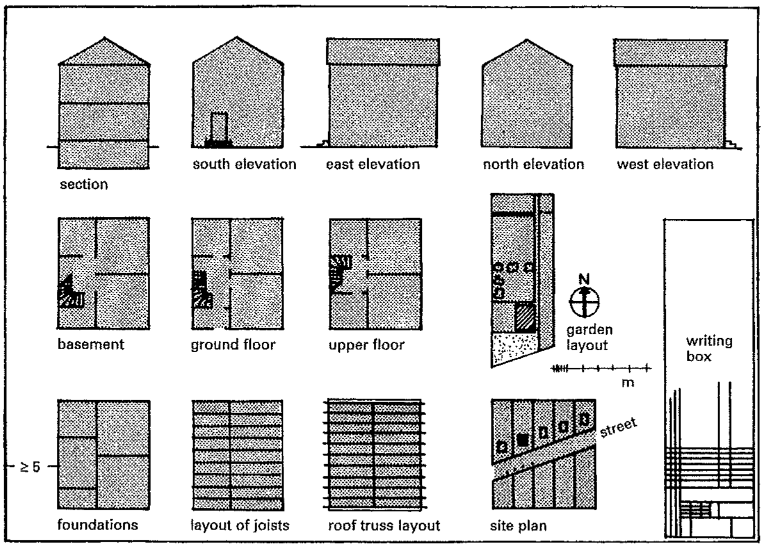
1. The title block must always be at the front, in the correct position and clearly visible.
2. At the start of folding, a width of 21 cm must always be folded first (fold 1), ideally with the use of a 21 × 29.7 cm template.
3. A triangle is folded into the drawing starting from **c** (fold 2) so that on the completely folded drawing only the below left field marked with a cross is punched or clamped.
4. The drawing is then folded parallel to side **a** to a width of 18.5 cm, for which a template of 18.5 × 29.8 cm is useful. The last section is folded in half to adjust the sheet size, bringing the title block to the front. Long narrow formats can be correspondingly folded.
5. The resulting strip is folded from side **b**.

A piece of card of size A5 = 14.8 × 21 cm can be glued to the back of the punched side to reinforce the edge. Any sheet size can be folded by following the instructions above. If the drawing length remaining after the folding of the first 21 cm cannot be divided by 18.5 cm into an even number 2, 4, 6, etc., then the remaining width should be folded in the centre.

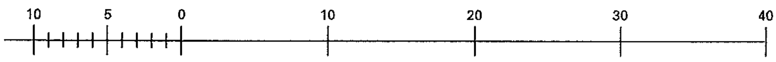
BS EN ISO 9431
BS EN ISO 10209
BS EN ISO 14617
DIN 406
DIN 825
DIN 1356

DRAWINGS

Layout of Drawings



❶ Suitable layout for a construction drawing



❷ Suitable layout for scale details

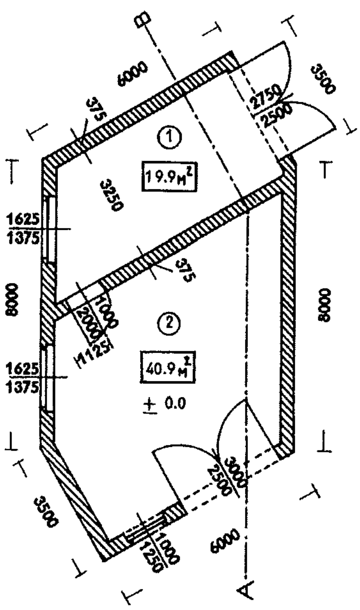
A strip 5 cm wide should be left blank at the left-hand edge for binding or filing. The title block on the right ❶ should include:

1. Description of the type of drawing (sketch, preliminary design, for construction etc.)
2. Category of building shown or type of drawing (layout plan, ground plan, section, elevation, diagram etc.)
3. Scale
4. If appropriate, details of dimensions.

Drawings for building permit applications (to the building regulations authorities) should also include:

1. Name (signature) of the client
2. Name (signature) of the architect
3. If required, (signature) of the site manager
4. If required, (signature) of the contractor
5. Comments by the building regulations authorities:
   a) About inspection
   b) About approval
   If necessary, on back of sheet

Layout plans, floor plans etc. should show the compass direction with a north pointer.



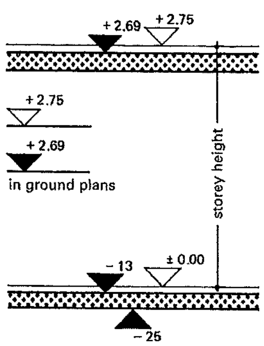
❸ Example of a standard dimensioned drawing of an angled floor plan. The dimensions given are structural dimensions without finishings

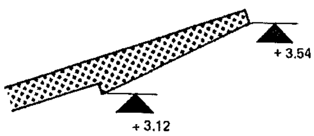
Scales → ❷
The main scale of the drawing should be shown in large letters in the title block and in smaller letters for other scales; the latter should be repeated next to their respective diagrams. All objects should be drawn to scale; dimensions of parts which are not drawn to scale should be underlined. Scales should be restricted to the following if at all possible:
for construction drawings 1:1, 1:5, 1:10, 1:20, 1:25, 1:50, 1:100, 1:200
for site layouts 1:500, 1:1000, 1:2000, 1:2500, 1:5000, 1:10000, 1:25000.

Dimensioning
Dimensioning is indicating dimensions on a drawing.
Levels should be given on sections and plans or elevations. The signs + or – before the number refer to the difference from level ± 0.00 (generally the planned finished floor level, on the ground floor in the entrance area, related to sea level). For parapets, the structural height above the structural slab level may also be given.
If the height of wall openings, particularly for doors and windows, is to be given on drawings in addition to their width, then the width measurement is given above the dimension line and the height measurement is given below it. Rectangular cross-sections can, as a simplification, be dimensioned by stating their side lengths as a fraction, e.g. 12/16 (in section: width/height).
Round cross-sections have the diameter sign ∅ before the measure: e.g. ∅ 12. Radii have the capital letter *R* before the measure.

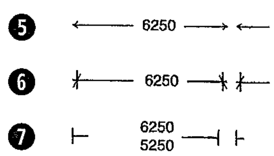
Dimensions and other markings → ❸
All dimensions are given in the unfinished structural condition (wall thicknesses). In continental Europe, dimensions of less than 1 m on building drawings are generally given in cm, dimensions over 1 m are given in m or mm. (However, recently the trend has been to give all dimensions in mm, which is standard practice in the **UK**.)

Sections on plans
On plans, vertical planes of one or more sections are shown as lines with short and long dashes → p. 9 ❶, and the direction of viewing is also given. The entire line of the section does not have to be shown, but if the plane of a section breaks, this does → ❸. If there is more than one section, then each should be clearly labelled.
Room numbers are given in a circle.
Room areas, in m², are shown in a square or rectangle → ❸.





❹ Marking of heights on sections and elevations



DRAWINGS
Paper formats
Technical drawings
Layout of drawings
Construction drawings
Construction drawing symbols
Water supply and drainage symbols
Electrical installation symbols
Security installation symbols
Gas installation symbols
Drawing by hand
Computer-aided drawing

BS EN ISO 4157
DIN 1356

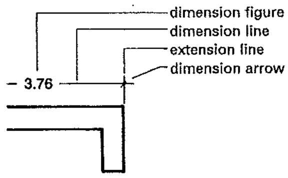
1	2	3	4	5	6
Line weight	Application	Line group			
		I	II	III[1)]	IV[2)]
		Scale			
		≦1:100		≧1:50	
		Line width (mm)			
solid line (heavy)	boundary of areas in section	0.5	0.5	1.0	1.0
solid line (medium)	visible edges and visible outlines of building elements, boundary of narrow or small building elements in section	0.25	0.35	0.5	0.7
solid line (fine)	dimension lines, extension lines, pointer lines, walking lines, outlines of cut-outs, simplified depictions	0.18	0.25	0.35	0.5
dashed line (medium)	hidden edges and hidden outlines of building elements	0.25	0.35	0.5	0.7
chain dot line (heavy)	indication of location of section planes	0.5	0.5	1.0	1.0
chain dot line (medium)	axes and centre-lines	0.18	0.25	0.35	0.5
dotted line (fine)	building elements in front of or over section plane	0.25	0.35	0.5	0.7
dimensions	text size	2.5	3.5	5.0	7.0

1) Line group I is only to be used when a drawing has been prepared with line group III, was reduced in the ratio of 2:1 and is to be worked on further. In this case, the text size 5.0 mm is to be selected for the drawing with line group III. Line group I does not fulfil the requirements for microfilming.
2) Line group IV is to be used for construction drawings if a reduction from scale 1:50 to scale 1:100 is intended and the reduction has to meet the requirements for microfilming. The reduction can then be further worked on using widths in line group II.

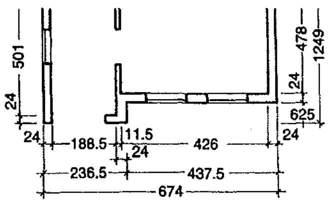
If building drawings are manually or mechanically drawn with ink and standardised drawing equipment, then the line widths according to the above should preferably be used. These widths are suitable for the usual application of common reproduction methods.

❶ Line types and thicknesses to be used in construction drawings

Dimensioning consists of: dimension figure, dimension line, extension line, dimension arrow → ❻.
Dimension figures are normally located above the relevant continuous dimension line so that they can be read from below or from the right when the drawing is used → ❷ + ❹.
Dimension lines are shown as solid lines → ❶. They are located parallel to the length being dimensioned.
Extension lines: dimensions which cannot be shown directly on the arrow at the edge of an area, are relocated outside with the aid of extension lines. These are generally at right angles to the dimension line and extend a little past it.



❻ Dimensioning terms

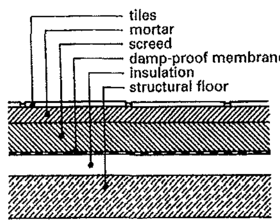


❷ Dimensioning outside the drawing (scale 1:100, units = cm)

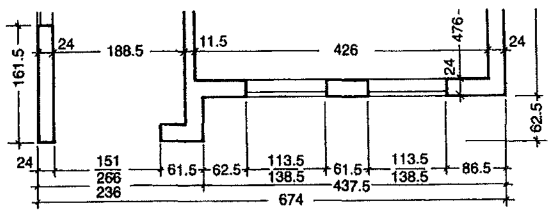
	1	2	3	4
	unit for dimensions	dimensions <1 m, e.g.	dimensions >1 m, e.g.	
1	cm	24	88.5	388.5
2	m and cm	24	88^5	3.88^5
3	mm	240	885	3885

NB Recent trend is to give all dimensions in mm, standard practice in UK → p. 6.

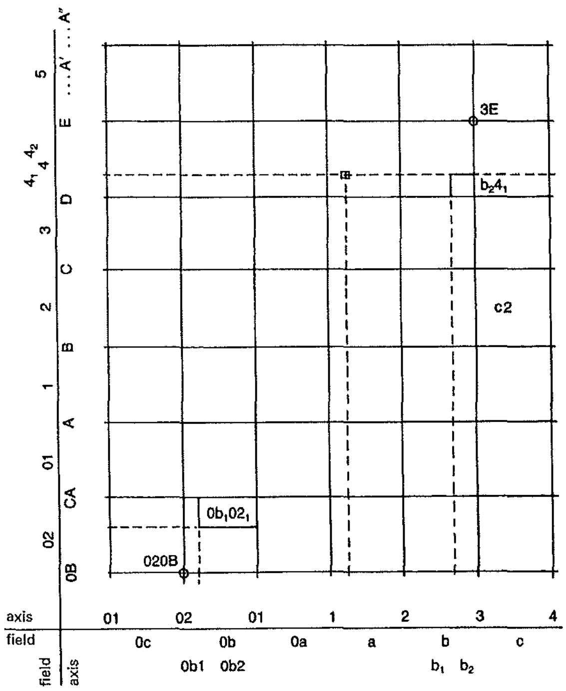
❸ Units for dimensions



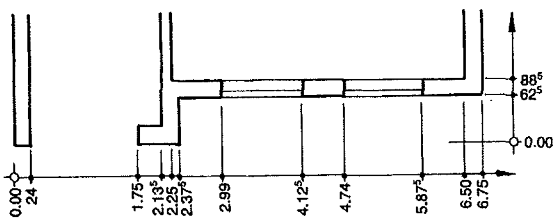
❼ Pointer lines to notes



❹ Dimensioning of pillars and openings, e.g. scale 1:50 cm, units = cm



❽ Axis-field grid

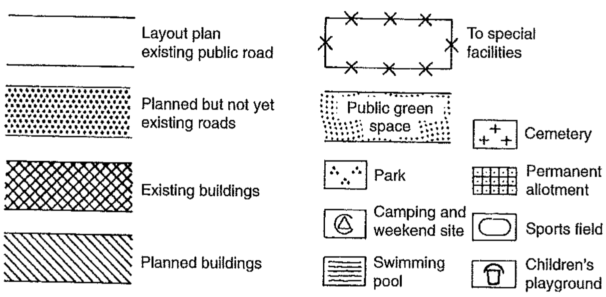


❺ Dimensioning with coordinates, e.g. scale 1:50 m, cm, units cm and mm

BS EN ISO 4157
DIN 1356

Monochrome	Colour	To be used for
	light green	grass
	sepia	peat dust and similar
	burnt sienna	ground
	black/ white	infilled earth
	brown-red	brick masonry in lime mortar
	brown-red	brick masonry in cement mortar
	brown-red	brick masonry in cement-lime mortar
	brown-red	porous brick masonry in cement mortar
	brown-red	hollow pot brick masonry in cement lime mortar
	brown-red	clinker block masonry in cement mortar
	brown-red	sand lime block masonry in lime mortar
	brown-red	alluvial stone masonry in lime mortar
	brown-red	stone masonry in mortar
	brown-red	natural stone masonry in cement mortar
	sepia	gravel
	grey black	slag
	zinc yellow	sand
	ochre	screed (gypsum)
	white	plaster
	violet	pre-cast concrete elements
	blue green	reinforced concrete
	olive green	unreinforced concrete
T	black	metal
	brown	timber in section
	blue grey	insulation materials
	black and white	sealants
	grey	existing building elements

❶ Symbols and colours used on plans and sections

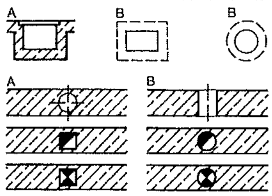


❷ Symbols for building permit applications

Building element	Opening	Dimensions	Location	Related to
C ceiling W wall F floor FO foundation	BR break-through G groove D duct	width × depth × height	u under o over	T top B bottom UF unfinished floor FF finished floor

❸ Labelling of openings: examples

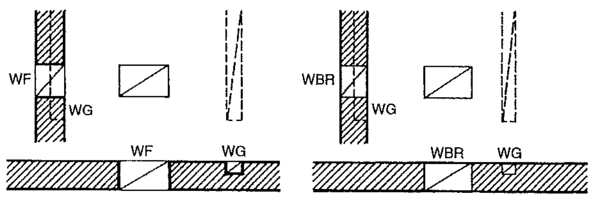
	Description	Label	Dimensions W	D	H	Depiction Plan	Elevation, (section, view)
Slab	slab breakthrough	SBR	A × B				
Slab	groove in slab (top)	GS	A × B × C				
Slab	groove in slab (underneath)	GS	A × B × C				
Lowest storey: floors, foundations	floor slab breakthrough (foundation = FO)	FSBR	A × B				
Lowest storey: floors, foundations	floor slab duct floor slab groove	FSD FSG	A × B × C				
Walls	wall breakthrough (foundation = FO dashed on basement plan)	WBR	A × C				
Walls	wall groove(horizontal) foundation = FO → ❸	WG	A × B × C				
Walls	wall groove (vertical) foundation = FO → ❸	WG	A × B × C				



A) Under floor duct in section
B) Same on plan

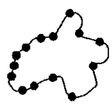
A) Pipe sleeve on elevation
B) Same on plan
Chimney on plan
Gas chimney on plan

❹ Presentation of openings, grooves and channels: examples

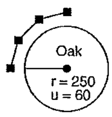


Closed in final state
Remains open

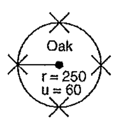
❺ Grooves , apertures and breakthroughs in walls



Natural monument (border with points) according to:
NSG = conservation area
LSG = landscape conservation area
GLB = Protected landscape element
§23 = under §23 HENatG protected habitat
GA = Population of particularly protected or threatened species

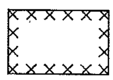


Tree protection
Tree with species, trunk centre, crown radius & trunk dia.
(Existing: full line, planned: dot-dash line



Tree to be removed with species, trunk centre, crown radius & trunk dia.

Group of bushes to be partly removed
Existing: full line
Planned: dot-dash line
To be removed: crossed-out full line



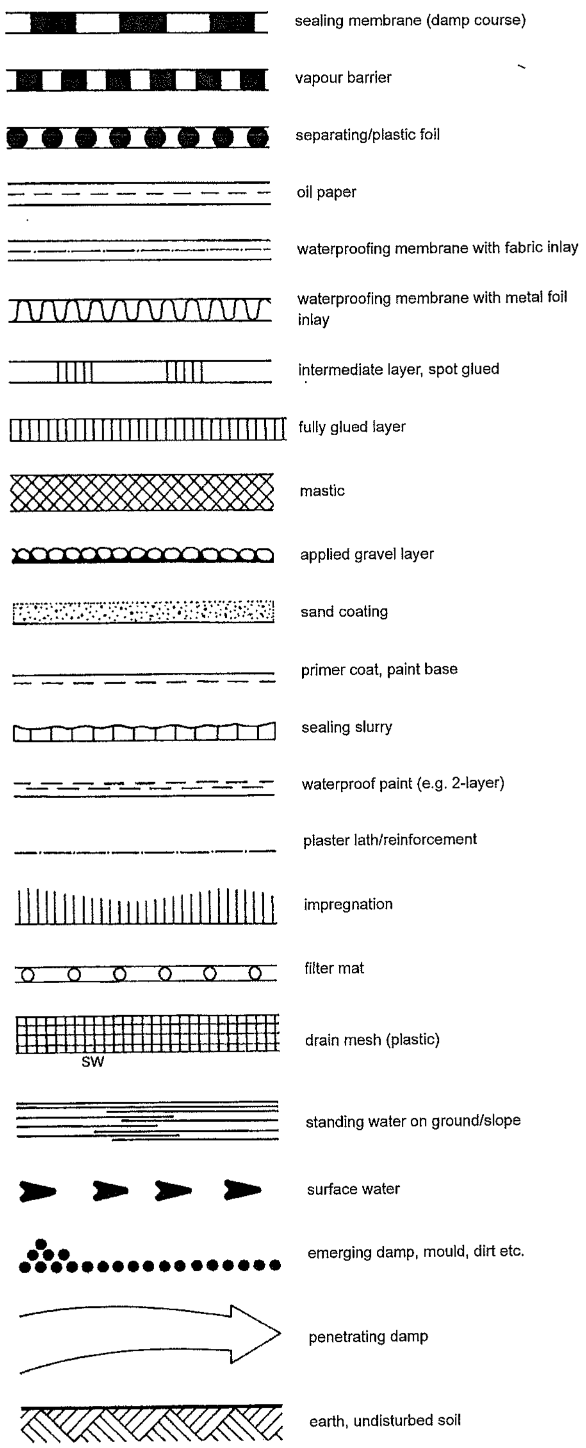
Border of area to be built on, whose soil is considerably contaminated with harmful substances.
Border of areas, whose soil is considerably contaminated with harmful substances.

❻ Symbols used in open spaces planning

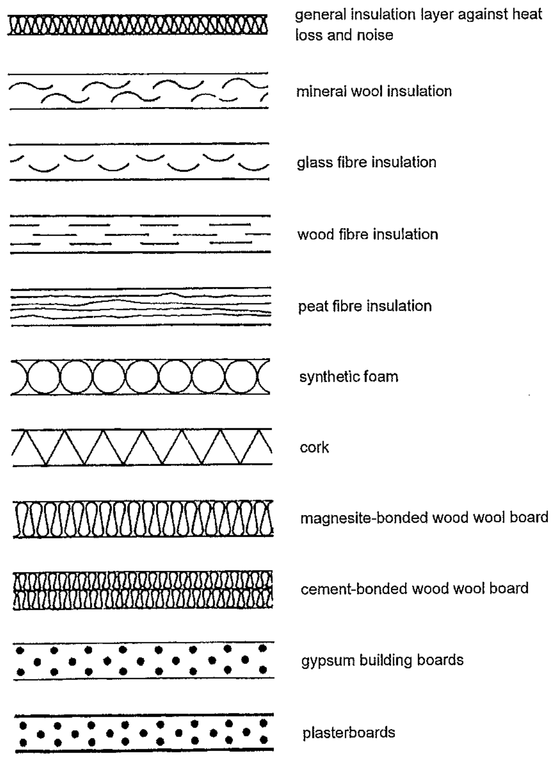
a) Floor surfaces
b) Ceiling surfaces
c) Wall surfaces
d) Clear window areas
e) Clear door areas
f) Flooring types
g) Type of paint or cladding to walls
h) Type of paint or cladding to ceilings

(a–c: Without deduction of openings; a–e: in m^2 with 2 figures after decimal point)

❶ Dimensions and other information, if required

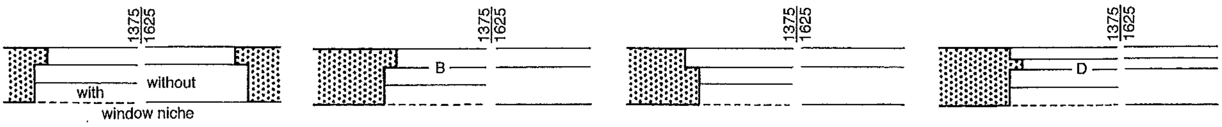


❷ Symbols for waterproofing, drainage, insulation, non-pressurised water etc.



❸ Symbols for insulation

Windows set in reveals, scale 1:100



❶ Single window opening inward gains space and offers a place for the radiator

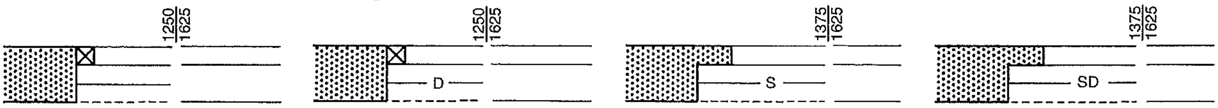
❷ Box window (B) opening inward, double window, combined window

❸ Single window opening outward

❹ Double window (D) opening outward

Sash window, scale 1:100

Sliding window, scale 1:100



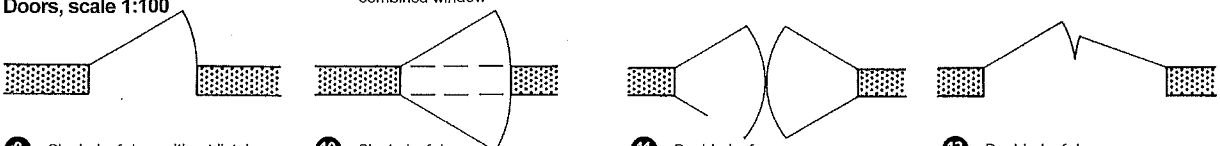
❺ Single window

❻ Double window (D), box window, combined window

❼ Single window (S)

❽ Double window (SD)

Doors, scale 1:100



❾ Single-leaf door without lintel

❿ Single-leaf door pair, with lintel

⓫ Double-leaf swing door

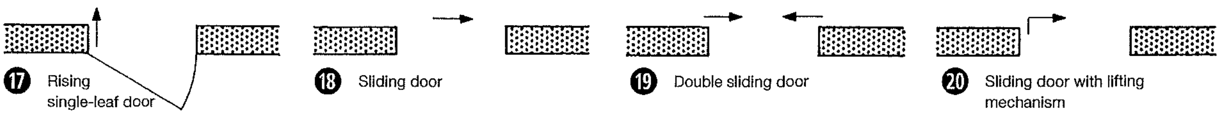
⓬ Double-leaf door

⓭ Pivoting door

⓮ Pivoting door

⓯ Without threshold

⓰ Threshold one side

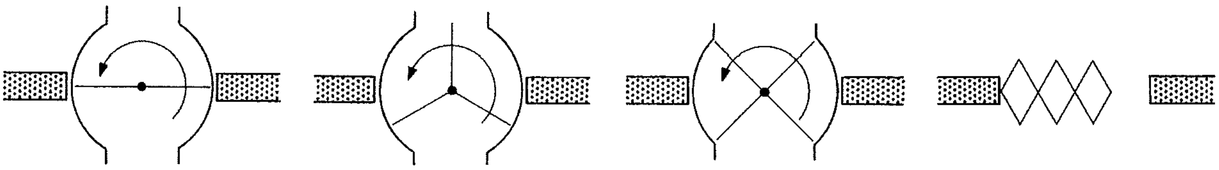


⓱ Rising single-leaf door

⓲ Sliding door

⓳ Double sliding door

⓴ Sliding door with lifting mechanism

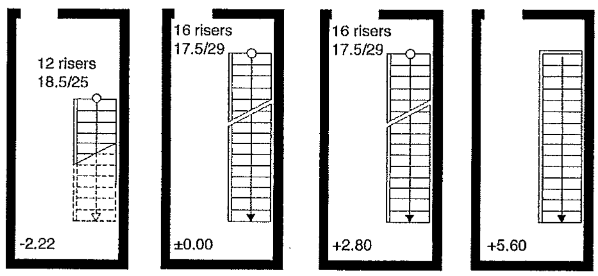


㉑ Two-leaf revolving door

㉒ Three-leaf revolving door

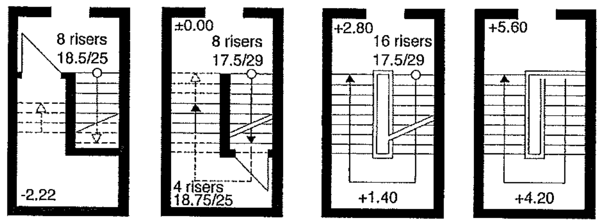
㉓ Four-leaf revolving door

㉔ Folding partition



Cellar Ground floor Upper floor Attic

㉕ Stairs with one flight



Cellar Ground floor Upper floor Attic

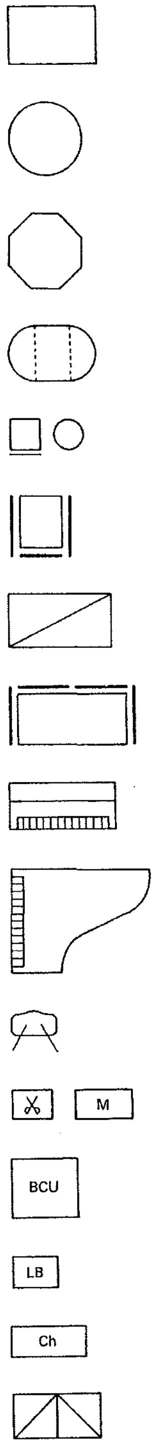
㉖ Stairs with two flights

When drawing **windows,** the left side is always shown with wall niche and the right side without → ❶ – ❽.

Revolving doors replace wind lobbies → ㉑ – ㉓ and offer an opening without draughts. Because revolving doors can cope with relatively little through traffic, the door leaves can be folded at peak times and pushed to the side.

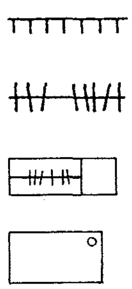
The horizontal section through the stairwell on each floor's plan is shown at about ⅓ storey height or 1 m above floor level. The steps should be continuously numbered upwards and downwards starting from ± 0.000. The number of steps below ± are preceded by a minus sign –. The numbers begin on the first step and exit on the landing. The centre-line starts at the first step with a circle and ends on arriving with an arrow (also in the cellar).

Living room



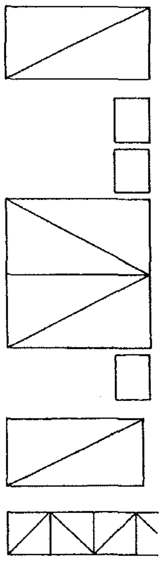
- table
  85 × 85 × 78 = 4 places
  130 × 80 × 78 = 6 places
- round table
  Ø 90 = 6 places
- shaped table 70 – 100
- pull-out table 120 × 180
- stool Ø 45 × 50
- armchair 70 × 85
- couch 95 × 195
- sofa 80 × 175
- upright piano
  60 × 140 – 160
- grand pianos:
  baby grand 155 × 114
  salon grand 200 × 150
  concert grand 275 × 160
- television
- sewing table 50 × 50–70
  sewing machine 50 × 90
- nappy changing
  table 80 × 90
- washing basket 40 × 60
- chest 40 × 100–150
- cupboard 60 × 120

Clothes storage



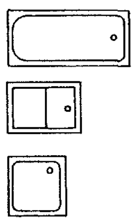
- hook spacing
  15–20 cm
- hanging rail
- clothes and linen
  cupboard 50 × 100–180
- desk
  70 × 130 × 78
  80 × 150 × 78

Bedroom



- bed
  100 × 200
- side table
  50 × 70, 60 × 70
- double bed
  100 × 200
- twin bed (French bed)
  145 × 200
- children's bed
  70 × 140 – 170
- clothes cupboard
  60 × 120

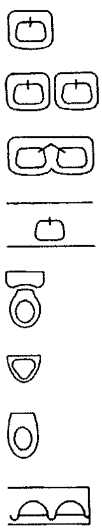
Bathroom



- bath
  75 × 170,
  85 × 185
- small bath
  70 × 105,
  70 × 125
- shower 80 × 80,
  90 × 90, 75 × 90

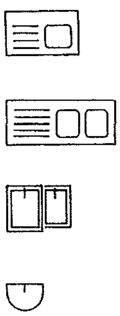
symbol
scale 1:100

symbol scale 1:50

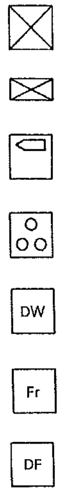


- washbasin 50 × 60,
  60 × 70
- 2 washbasins
- double washbasin
  60 × 120, 60 × 140
- vanity unit 45 × 30
- WC 38 × 70
- urinal 35 × 30
- bidet 38 × 60
- urinal stand

Kitchen

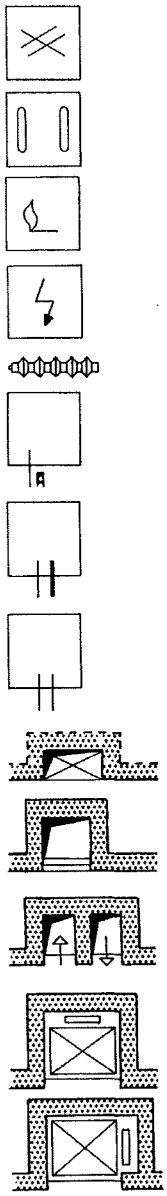


- sink 60 × 100
- double sink 60 × 150
- stepped sink
- kitchen bucket sink



- floor cupboard
- wall cupboard
- ironing board
- electric oven
- dishwasher
- refrigerator
- chest freezer

Stoves with fuel type



- solid fuel
- oil
- gas
- electric
- radiator
- heating boiler with grate
- gas-fired
- oil-fired
- waste disposal unit
- waste chute
- air supply and extraction
  shaft
- PTL = patient lift
  GL = goods lift
  PL = passenger lift
  FL = food lift (paternoster)
  HL = hydraulic lift

BS EN 12056
DIN 1451
DIN 1986

Drainage pipes and appliances

Plan	Elevation	Description
DS	DS	pressurised blackwater pipe is marked with DS
DR	DR	pressurised rainwater pipe is marked with DR
		mixed water pipe
		ventilation duct, direction given, e.g. starting and running upward
according to type		stack, downpipe
a) b) c) d)		direction: a) passing through b) starting and running downward c) coming from above and ending d) starting and running upward
		change of material
		pipe end closed
		cleaning opening, round or rectangular
		cleaning opening
100 125	100 125	change of nominal diameter
		odour trap
		outlet or drainage gutter without odour trap
		outlet or drainage gutter with odour trap
		waste outlet with backflow device for faeces-free wastewater
F	F	fat separator
St	St	starch separator
B	B	petrol interceptor (separator for volatile liquids)
S	S	silt trap
SA	SA	acid separator
H	H	heating oil separator (separator for volatile liquids)
H Sp	H Sp	heating oil stop valve
H Sp	H Sp	heating oil stop valve with backflow preventer
		backflow device for faeces-free wastewater
		backflow device for wastewater containing faeces
		shaft with open through-flow (shown with blackwater pipe)
		shaft with closed through-flow

Water supply

Plan	Elevation	Description
		cellar drainage pump
		blackwater lifting system
		bath
		shower tray
		vanity unit, hand washbasin
		sitting washbasin
		urinal
		urinal with automatic flushing
		WC, floor-mounted
		WC, wall-mounted
		slop sink
		single sink
		double sink
		dishwasher
		washing machine
		washer/dryer
		air conditioner

Symbol	Description
	small wastewater treatment plant, two-level
	small wastewater treatment plant, multi-level
	small wastewater treatment plant, multi-leve
	small wastewater treatment plant, multi-level
	soakaway shaft
	underfloor hydrant
	above-floor hydrant
	fire fighting hose connection pipe

Description	Symbol
wet riser pipe	F
wet-dry riser pipe	FNT
dry riser pipe	FT
sprinkler pipe	F SPR
sprinkler system	
spray flooding system	
water spray system	

Water supply *(continued)*

- water pipe
- marking of location of shut-off or throttling valve
- marking of location of supply valve
- detachable connection
- non-detachable connection
- hose
- apparatus without rotating parts
- apparatus with rotating parts, display or registration instrument
- display or recording instrument
- measuring instrument built into pipe
- TW 80 — drinking water pipe, cold, e.g. Ø 80
- TWW 50 - WD — drinking water pipe, warm, e.g. Ø 50
- TWZ 40 — drinking water pipe, circulation, e.g. Ø 40
- TW 15 — drinking water pipe, hose, e.g. Ø 15
- 50 / 40 — marking of location for change of nominal diameter, e.g. from Ø 50 to Ø 40
- 50 / 40 — as above but also as reducer fitting
- ST / CU — marking of location for change of material, e.g. from steel to copper
- crossing pipes (without connection)
- branch, one-sided
- branch, two-sided
- riser pipe
- direction:
  - a) passing through
  - b) starting and running upward
  - c) coming from below
  - d) starting and running downward
  - e) coming from above and ending
- electrical separation, isolation piece
- potential equalisation, earthing
- expansion bend
- length compensator, wave pipe compensator
- sealing bush compensator
- pipeline fixed point
- sliding pipe fixing
- 5 — pipe fall, pipe rise, e.g. 5%
- wall or slab opening with protecting sleeve

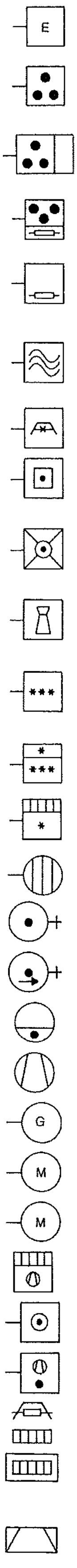
- wall or slab opening with protecting sleeve and stopping
- end of pipe
- detachable connection, general type of connection can be simplified by use of short code
  - S screwed connection
  - T-RL threaded connection with right-left thread
  - F flange connection
  - C coupling
  - SK socket connection
  - CL clamped connection
- flange connection
- screw connection, threaded connection
- socket connection
- coupling
- type of connection can be simplified by use of short code
  - W welded connection
  - S soldered connection
  - G glued connection
  - T threaded connection
  - SK socket connection
  - P pressed connection
- shut-off valve, general
- shut-off gate valve
- shut-off flap valve
- shut-off valve, through-flow valve
- type of connection can be simplified by use of short code
  - SD screw-down valve
  - SS slanted seat valve
  - T throttle valve
  - BP valve behind plaster
- elbow valve
- three-way valve
- four-way valve
- through-flow valve
- type of connection can be simplified by use of short code
  - T tap cock
  - B ball valve
- three-way tap
- four-way tap
- clamped tapping (e.g. at side)
- clamped tapping with valve (e.g. top)
- pressure reducer, pressure stopcock

- bleed valve, emptying valve
- wall battery
- free-standing battery
- mixer
- S — flushing cistern
- shower head
- shower hose
- self-closing valve
- pressure flusher
- pipe anti-vacuum device and bleeder
- pipe anti-vacuum device and bleeder with dripping water pipe
- pipe ventilator
- pipe ventilator, through-flow
- pipe bleeder
- pipe interrupter
- backflow preventer
- through-flow valve with backflow preventer
- outlet valve with ventilator and threaded hose connection
- draw-off tap with backflow preventer, ventilator and threaded hose connection
- pipe rupture valve, hose rupture valve
- free outlet, system separation
- pipe disconnecter
- safety valve, spring-loaded
- elbow safety valve, spring-loaded
- DOS — metering device

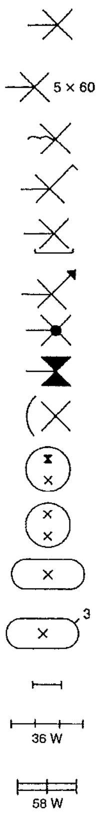
- EH — water softener, demineralisation plant
- FIL — filter
- pump
- 1 / 30 m³/h / 5 — booster pump
- washing machine
- dishwasher
- washer/dryer
- air conditioner
- flow gauge, through-flow gauge
- flow meter, water meter
- calorimeter
- connection for measuring instrument
- thermometer
- pressure gauge
  type of gauge can be indicated by use of short code
  - Δp differential pressure gauge
  - pτ pressure pulse generator
- logger
  if required, mark type of device with short code
  - v through flow
  - v volume
  - T temperature
  - Δp pressure difference
- control cable
- fluid-driven
- float-driven
- weight-driven
- spring-driven
- manual
- electricity-driven
- membrane-driven
- piston-driven
- electromagnet-driven
- container, non-pressure, open, with overflow

BS EN 12056
DIN 1451
DIN 1986

Electrical consumer appliances

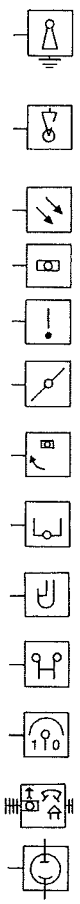


- electrical appliance, general
- electric stove with three rings
- electric stove with built-in coal oven
- electric stove with oven for baking
- oven for roasting and baking
- microwave cooker
- infra red grill
- warming plate
- dishwasher
- food processor
- refrigerator, e.g. freezer compartment, no. stars
- freezer, no. stars
- air conditioner
- water heater, general
- hot water storage cylinder
- continuous-flow water heater
- fryer
- fan
- generator, general
- motor, general
- motor with statement of protection type
- hand dryer, hair dryer
- washing machine
- washer/dryer
- infra red lamp
- room heating, general
- storage heater
- electrically heated clear-view screen

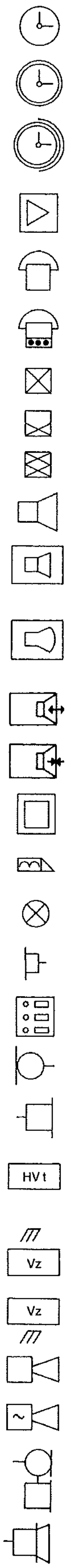


- light fitting, general
- multiple light fitting stating no. lamps and power, e.g. five lamps at 60 W
- adjustable light fitting
- light fitting with switch
- light fitting with current bridge for lamp chains
- light fitting, dimmable
- panic light
- emergency light
- searchlight
- light fitting with additional emergency light
- light fitting with two separate filaments
- light fitting for discharge lamps with accessories
- light fitting for discharge lamps with details
- light fitting for fluorescent lamp, general
- light band, e.g. three lamps at 36 W
- light band, e.g. two lamps at 2 × 58 W

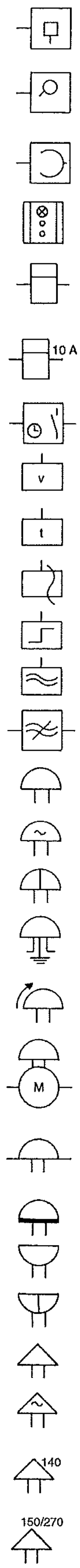
Signal and radio devices



- motion detector, e.g. with safety circuit
- vibration detector (safe pendulum)
- light beam detector, light barrier
- press-knob fire alarm
- automatic fire alarm
- police alarm
- fire alarm with drive
- fusible link alarm, automatic
- automatic temperature alarm
- automatic extension fire alarm
- pass lock security systems
- centre of fire alarm system
- light beam alarm system, automatic, e.g. photo cell



- secondary clock
- main clock
- main clock with signal
- amplifier, cable peak denotes amplification direction
- telephone, general
- multiple telephone
- telephone, long-distance
- telephone, semi-internal
- telephone, internal
- loudspeaker
- radio
- television
- intercom, e.g. house or door entry phone
- two-way intercom, e.g. house or door entry phone
- telephone exchange, general
- door opener
- alarm lamp, signal lamp, light signal
- bell button
- call buttons with name labels
- microphone
- earpiece
- main distributor (communications)
- splitter, flush
- splitter, surface-mounted
- beeper or horn, general
- beeper or horn stating current type
- house intercom
- entry phone



- sound recorder
- sound pick-up
- magnetic tape recorder
- call and switch off panel
- meter
- meter panel, e.g with a fuse
- time clock, e.g. for switching tariff
- temperature detector
- time relay, e.g. for stair lighting
- blink relay, blink switch
- current impulse switch
- sound frequency ripple control relay
- sound frequency cut-off
- alarm clock, general
- alarm clock, stating current type
- gong alarm clock
- alarm clock for safety circuit
- alarm clock with run-down drive
- motor alarm clock
- alarm clock without automatic cancel, continuously ringing alarm clock
- alarm clock with visual alarm
- buzzer
- buzzer
- siren, general
- siren stating current type
- siren stating frequency, e.g. 140 Hz
- siren with wailing tone, e.g. varying between 150 and 270 Hz

DRAWINGS

Electrical Installation Symbols

Electricity

- direct current
- A — alternating current, general
- 2 kHz — stating the frequency
- T — technical alternating current
- direct current or alternating current (universal current)
- mixed current
- sound frequency alternating current
- high frequency alternating current
- very high frequency alternating current

Supporting points in mast cables

- cable, general
- underground cable
- support point, mast, general
- guyed mast
- timber mast
- roof stands, brackets, tubular mast, general
- guyed mast
- lattice mast, general
- guyed mast
- reinforced concrete mast, general
- guyed mast
- mast with foot
- double mast
- transverse H-mast or portal mast
- portal mast of lattice masts
- lengthwise A-mast
- support point with tension anchor
- support point with brace
- mast with lamp

Cables and cable connections

- existing
- under construction
- planned
- mobile cable
- underground cable
- overground cable, e.g. mast-mounted
- cable on porcelain isolators (isolation bells)
- cable on surface of plaster
- cable plastered in
- cable beneath plaster

- isolated cable in installation duct
- (t) — isolated cable for dry rooms, e.g. sheathed wire
- (f) — isolated cable for wet rooms, e.g. wet room cable
- (k) — cable for outdoor or underground laying

Cables, marking, application

- protection cable, e.g. for earthing, neutralisation or protection circuit (old)
- signal cable
- telephone cable
- radio cable
- cable with marking
- 3 — simplified depiction
- protective earth cable (PE)
- PEN cable
- neutral cable
- Cu 20 × 4 — conductor rail
- foreign cable
- + + + + + +, X-X-X-X-X, O-O-O-O-O, -I-I-I-I-I- — further markings, e.g. telephone, night circuit, blinking light cable, emergency lighting cable
- twisted cable, e.g. two-wire
- coaxial cable
- rectangular hollow cable, e.g. for very high frequency
- cable running upward
- cable running downward
- cable running upward and downward
- cable connection
- branch connection box, depiction if necessary
- socket
- sealing end, end branch
- high-voltage house connection box, general
- IP 54 — as above, stating protection type
- distribution
- framing for devices, e.g. housing, switching cabinet, switching panel
- earthing, general
- connection point for earth wire
- mass, body
- element, accumulator or battery
- 230/8V — transformer, e.g. doorbell transformer

- converter, general
- rectifier, e.g. alternating current mains connection
- rectifier, e.g. pole changer, chopper
- fuse, general
- screw-in fuse, e.g. 10A and type DII, three-pole
- low-voltage high-performance fuse, e.g. 50A size 00
- 3 — trip, e.g. 63A, three-pole
- switch, make contact
- 4 — earth leakage circuit breaker, four-pole
- B 16A, 3 — cable protection switch, e.g. 16A, three-pole
- 3 — motor protection switch, three-pole
- I > — excess current switch, e.g. ballast switch
- emergency off switch
- star-delta switch
- 5 — starter, rheostat, e.g. with five starting steps
- button switch
- light switch
- switch with indicator light
- switch 1/1 (off switch, single-pole)
- switch 1/2 (off switch, two-pole)
- switch 1/3 (off switch, three-pole)
- switch 4/1 (group switch, single-pole)
- switch 5/1 (series switch, single-pole)
- switch 6/1 (two-way switch, single-pole)
- Z — two-way switch as pull switch
- switch 7/1 (cross-switch, single-pole)
- t — time switch
- dimmer
- approach switch
- contact switch

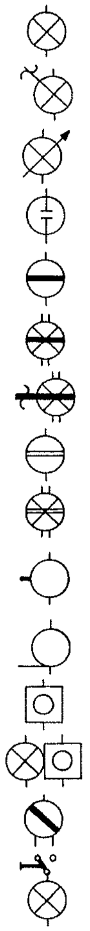
- approach effect, general
- contact effect, general
- passive infra red motion detector
- t — time relay, e.g. for stair lighting
- current impulse switch
- empty connection box
- 3 — multiple socket
- single earthed socket
- 3/N/PE — as above but for three-phase current
- double earthed socket
- socket with off switch
- socket, lockable
- depiction of vertical if required
- socket for isolating transformer
- E — electrical connection, general
- E 3/N/PE — three-phase connection
- smoke extraction ventilator switch
- RWA — smoke extraction press-button alarm
- fire alarm (press-button alarm)
- EDV — IT connection socket
- BK — broadband communications system
- Vt — telephone distributor
- telephone socket
- aerial socket
- aerial splitter, e.g. twice
- aerial distributor ,e.g. twice
- aerial amplifier
- aerial socket (through sockets)
- aerial socket with end resistance

BS EN 50110
DIN 18015

BS EN 50110
DIN 18015

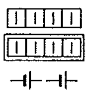
Electrical Installation Symbols

Visual indicators



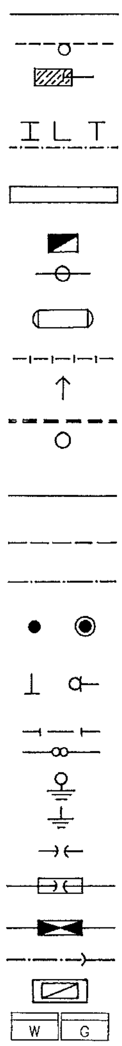
- indicator light, general
- blinking indicator light with direction pointer
- indicator light with darkening switch
- indicator light with glimmer light
- pointer indicator with automatic return
- pointer indicator with automatic return, lit
- pointer indicator with automatic return, lit or swinging
- pointer indicator without automatic return
- pointer indicator without automatic return, lit
- indicator with filling device
- recording indicator
- meter
- meter with indicator lamp
- multiple detector
- acknowledgement detector

Batteries



- elemental battery
- accumulator battery (four cells)
- element, accumulator

Lightning protection installations



- building outline
- gutter and downpipe
- reinforced concrete with connection
- steel construction, metal rails
- metal covering
- chimney
- roof stands for electric lines
- diaphragm tank, tank
- snow guards
- aerial
- metal pipe
- lightning conductor, open
- lightning conductor, underground
- lightning conductor, under roof and under plaster
- terminal pole, flagpole
- connection point to pipes
- separation point
- pipe and rod earth terminal
- earthing
- sparking distance
- closed sparking distance
- excess voltage discharge conductor
- roof fixing
- lift
- water meter, gas meter

No.	Type of appliance	No. (min.) of Sockets[1]	No. (min.) of Outlets	Connections for appliances of ≧2 kW	Connected load (kW) AC	Connected load (kW) 3-phase
	Living room and bedroom					
	sockets[2], lighting					
1	for living area up to 8 m^2	2	1			
2	8–12 m^2	3	1			
3	12–20 m^2	4	1			
4	>20 m"	5	2			
	Kitchen, kitchenette					
	sockets, lighting					
5	for kitchenette	3	2[3]			
6	for kitchen	5	2[3]			
7	ventilator/extractor hood		1[4]			
8	stove			1		8.0–14.0
9	refrigerator/freezer	1			0.2	
10	dishwasher			1	3.5	4.5
11	water heater			1[5]	2.0	4.0–6.0
	Bathroom					
12	sockets, lighting	2[6]	2[7]			
13	extractor fan		1[4], [8]			
14	washing machine[9]			1[10]	3.3	7.5
15	heater					
16	water heater			1[5]	2.0	4.0–6.0
	WC					
17	sockets, lighting	1[11]	1			
18	extractor fan		1[4], [8]			
	Utility room					
19	sockets, lighting	3	1[3]			
20	extractor fan		1[4]			
21	washing machine			1[12]	3.3	7.5
22	washer/dryer			1[12]	3.3	
23	ironing machine			1	2.1–3.3	
	Hall, corridor					
	Sockets, lighting					
24	for length up to 2.5 m	1	1[13]			
25	over 2.5 m	1	1[14]			
	Outdoor sitting area					
26	sockets, lighting	1	1[15]			
	Storeroom >3 m²					
27	lighting		1			
	Hobby room					
28	sockets, lighting	3	1			
	Residential cellar and basement [16]					
29	sockets, lighting	1	1			
	Commercial cellar and basement					
	Sockets, lighting					
30	for usable area up to 20 m^2	1[17]	1			
31	over 20 m^2	1[17]	2			
	Cellar and basement passage					
32	lighting		1[18]			

1) Or junction boxes for consumer devices <2 kW.
2) Sockets next to beds are double sockets, which, arranged next to aerial sockets, are triple sockets. These multiple sockets, are counted in the table as single sockets.
3) The worktops should be lit with as little shadow and glare as possible.
4) If a single extract fan is to be provided.
5) Unless hot water is provided by other means.
6) Of which one may be combined with the vanity unit light.
7) For bathrooms with 4 m^2 usable area, one connection above the vanity unit is sufficient.
8) For bathrooms and WCs without windows, the switch is via the general lighting, with a time lag.
9) In residential property necessary only once.
10) Unless a utility room is provided or the appliances can be accommodated in another suitable room.
11) For WCs with a vanity unit.
12) Unless accommodated in the bathroom or another suitable room.
13) Switchable from one location.
14) Switchable from two locations.
15) From 8 m^2 usable space.
16) Does not apply to cellar and basement rooms with grating-like partitions, e.g. wire mesh.
17) For signal amplifiers, only required once per system.
18) For passages >6 m long, one outlet every 6 m of length begun.

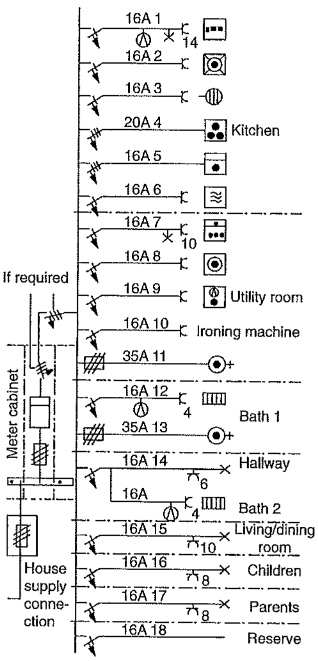
❶ Power supply to electrical appliances

Living area (m^2)	No. circuits for lighting and sockets
up to 50	2
50–75	3
75–100	4
100–125	5
over 125	6

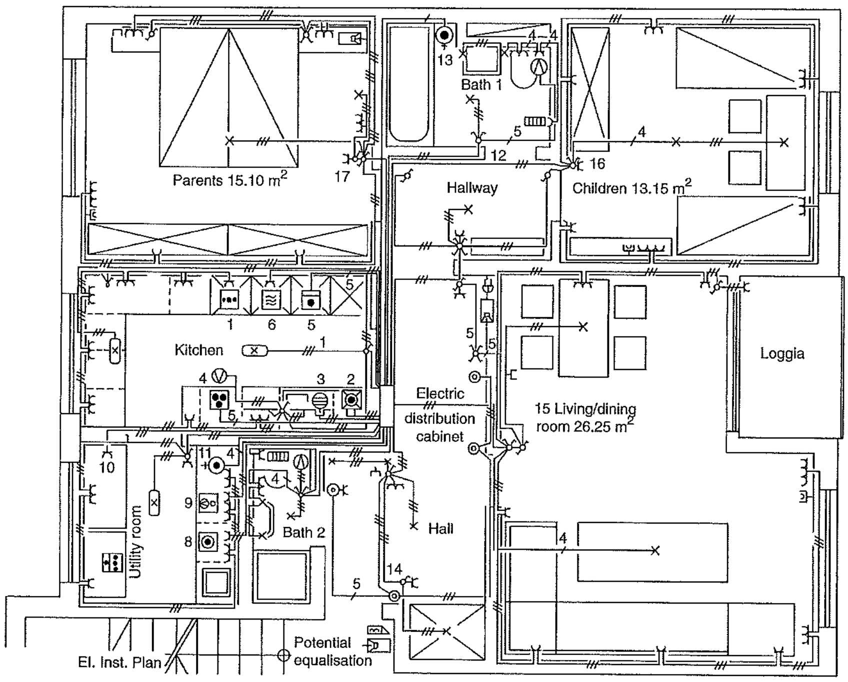
❷ No. circuits by size of living area

Living area (m^2)	No. circuits for lighting and sockets
up to 45	3
45–55	4
55–75	6
75–100	7
over 100	8

❸ High level of equipment



❹ Circuit diagram



❺ Electrical installation plan

Burglar alarm systems

- strike plate contact
- opening contact
- magnetic contact
- vibration sensor
- oscillation contact
- thread tension switch
- foil
- breakthrough sensor
- pressure sensor/step mat
- glass breakage sensor
- structure-borne sound sensor
- passive infrared sensor
- light barrier
- light sensor
- image detector
- microwave doppler motion detector
- microwave barrier
- HF field alteration sensor
- LF field alteration sensor
- capacitive field alteration sensor
- HF barrier
- ultrasound doppler motion detector
- ultrasound barrier
- banknote contact
- attack detector
- electromechanical switchgear
- mental switchgear
- time clock switchgear
- light switch device
- acoustic signal generator
- optical signal generator
- connection relay
- remote switching device
- alarm searchlight

Fire alarm systems

- maximum heat detector
- differential heat detector
- optical smoke detector
- ionisation smoke detector
- infra red flame sensor
- ultra violet flame sensor
- pressure sensor (sprinkler activation)
- manual alarm
- connection relay
- fire brigade key depot

Control centres/accessories

- ÜEM attack and break-in alarm control centre
- 3M fire alarm control centre
- ZK access control centre
- FÜ CCTV surveillance control centre
- LD shop theft alarm control centre
- WS intercom control centre
- TÖ door opener control centre
- converter
- transmission system
- analog-digital converter
- mains rectifier
- accumulator battery
- automatic dialling and announcement device
- recording system handle
- connection relay
- digital line coupler
- analog-digital converter with line coupler signal flow device
- display tableau
- operating panel
- housing
- monitored housing
- monitored distributor

CCTV surveillance systems

- TV camera
- TV camera with varifocal lens
- TV camera protective housing
- protective housing with pan and tilt head
- TV camera with pan and tilt head
- TV camera with motion detector
- monitor
- operating panel view selection device
- monitor with video signal-dependent picture switching

Access control systems

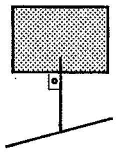
- pass reader
- stand-alone reader with additional code entry
- online reader
- pass reader with additional code entry
- stand-alone reader with additional code entry
- data terminal with operating panel
- man lock
- turnstile
- revolving door
- electrically unlocked door
- electrically opened door
- overlight
- protective grille
- security escutcheon
- long security handle plate
- tilt and turn window casement lock
- lock for four-sided key
- falling bolt lock
- deadbolt lock
- hinge bolts (dog bolts)
- roller shutter locking
- folding shutter locking
- two-key lock system
- lockable window handle
- security strike plate
- cross-bolt lock, double bolt lock
- cellar grating security
- cylinder lock
- vertically sliding door lock
- fence
- barbed wire fence
- solid fence, mesh
- R roller shutter with closing security
- SR steel roller shutters
- GR roller or concertina shutter
- G safe
- VSG laminated safety glass

Gas installations

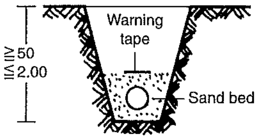
- exposed horizontal pipe (stating nominal diameter) — 25
- concealed horizontal pipe (stating nominal diameter)
- change of cross-section (stating nominal diameter)
- gas pipe house entry
- isolating piece
- riser pipe
- continuously rising pipe
- downpipe
- crossing of two pipes without connection
- crossing connection
- branch location
- cleaning T-piece — RT
- cleaning K-piece — RK
- long-threaded connection
- screwed connection
- flanged connection
- welded connection
- shut-off tap
- shut-off gate valve
- shut-off valve
- thermally activated shut-off device
- elbow valve
- pressure regulator
- gas meter — Z
- gas stove (four rings)
- gas oven (four rings)
- gas refrigerator — G
- gas heat pump
- exhaust gas/flue pipe (stating diameter) — 80ø
- exhaust gas systems (stating dimensions), also for exhaust gas flue/chimney — CM
- filter
- gas room heater
- continuous flow gas water heater — G
- combi gas water heater — G
- gas storage water heater — G
- gas room heater for external wall connection (stating connection capacity) — m³/n
- gas heating boiler — G
- flexible hose

Gas appliance	Heating capacity (kW)	Gas volume flow (m^3/h)
gas water heater	8.8–28.1	1.14–3.62
circulating water heater	9.5–28.4	1.23–3.67
storage water heater	5.1–13.9	0.70–1.91
heating stove/boiler	2.6–60.3	0.34–7.79

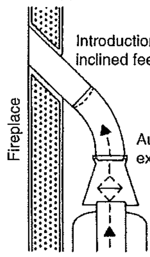
❶ Connection specifications for gas appliances



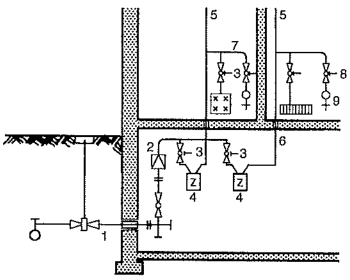
❷ House supply connection at right angles to front of building



❸ Gas pipe laid on undisturbed soil; does not have to be frost-free

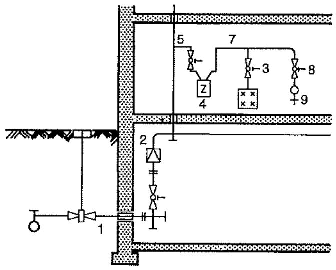


❹ Flow-operated safety device and flue gas flap valve

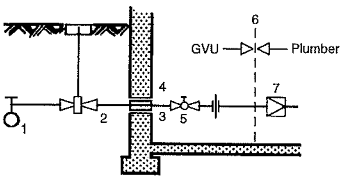


❺ Gas meter in cellar

1 house introduction combination
2 pressure regulator
3 shut-off
4 gas meter
5 riser
6 gas supply line
7 branch line
8 devices connecting fitting thermally activated device
9 gas equipment: stove, water heater

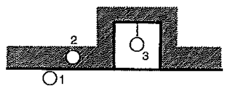


❻ Gas meters on each storey



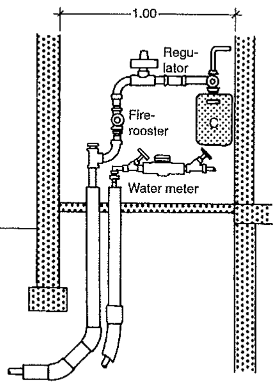
❼ Gas supply

1 power cable, local area network management
2 steel service pipe
3 casing
4 pull out
5 shut off the main with integrated insulating joints
6 boundary between gas valve unit (GVU) and installer
7 pressure regulator

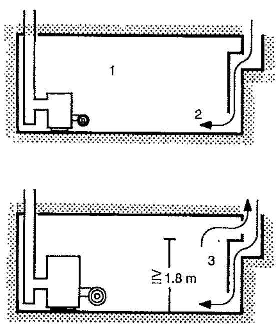


1 A gas line installed free, gas lines can also be laid outside the building, such as a gas heater on the roof. A gas line needs to be frost-free.
2 Gas pipe laid under plaster.
3 Gas pipelines in shafts or channels have to be loaded and ventilated. Openings approximately 10 cm^2. For suspended ceilings, these openings are placed diagonally.

❽ Laying gas pipes

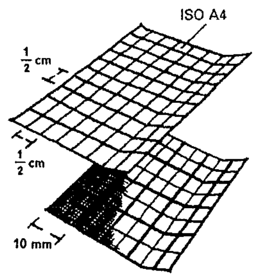


❾ House supply connection for water and gas in one compartment 1 m wide and 0.30 m deep

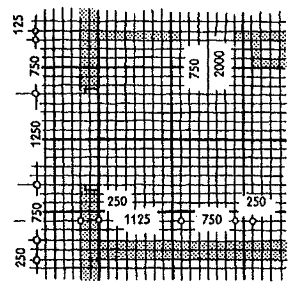


❿ **Heating room ≧35 kW**

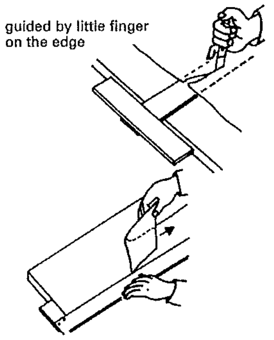
1 Minimum size 1 m^3/kW
2 Combustion air opening in boiler output to ≧50 kW cm^2 at ground level
3 Combustion air opening at about 50 kW boiler capacities. Cross-section of the opening of 150 cm^2 per kW + 2cm^2, the over 50 kW goes out. Example: boiler output 65 kW 50 kW + 15 kW 150 cm^2 + (15 × 2 = 30) cm^2 = 180 cm^2



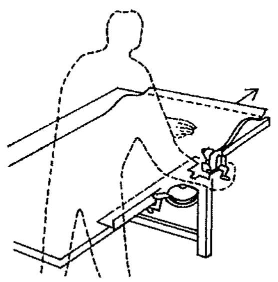
❶ Sketching paper

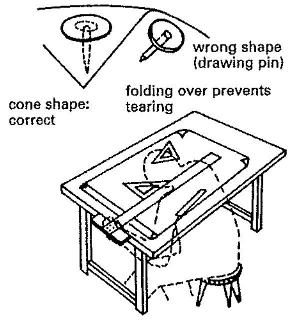


❷ Sketching: construction engineering grid

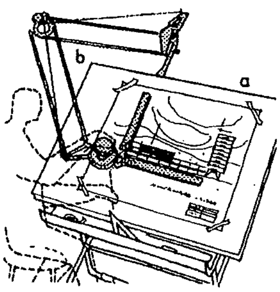


❸ Cutting paper to size

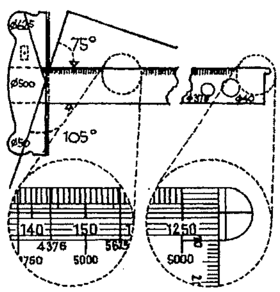

❹ Reinforcing edges



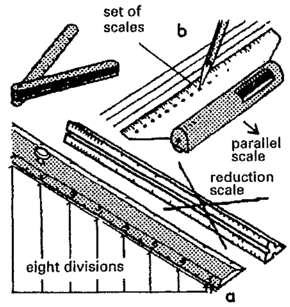
❺ Drawing board



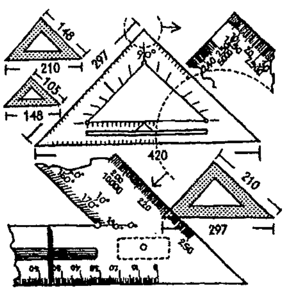
❻ Drafting machine



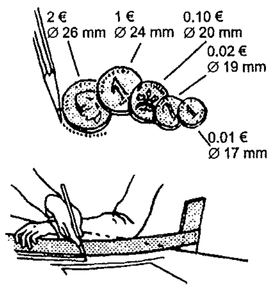
❼ Specialised T-square



❽ Drawing aids

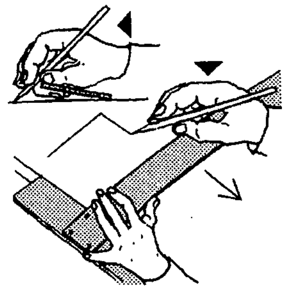


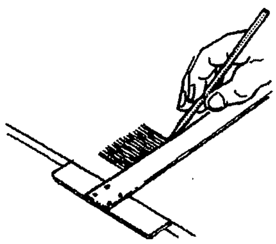
❾ Set squares

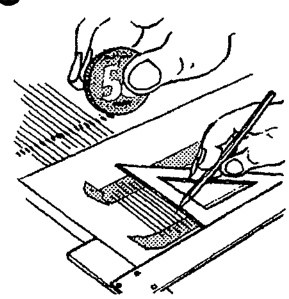


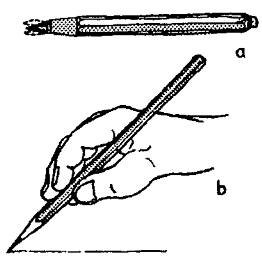
❿ Drawing aids


⓫ French curves


⓬ Good drawing practice


⓭ Drawing aid


⓮ Aid for hatching



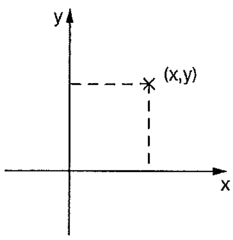
⓯ a) Clutch pencil (lead holder);
b) Correct way of holding pencil

Designers use drawings and diagrams to communicate information in a factual, unambiguous and geometric form that can be understood anywhere in the world. Unlike painting, construction drawing is a means to an end, and this differentiates diagrams/working drawings and illustrations from artistic works. A4 sketch pads with 0.5 cm squared graph paper are ideal for freehand sketches to scale. For more accurate sketches, millimetre graph paper with thick centimetre, faint 0.5 cm and even finer millimetre divisions should be used → ❶. Different paper is used for drawing and sketching according to standard modular coordinated construction and engineering grids → ❷. Use tracing paper for sketching with a soft lead pencil. Suitable sheet sizes for drawings can be cut straight from a roll, single pages being torn off using a T-square → ❸ or cut on its underside → ❸. Construction drawings are done in hard pencil or ink on clear, tear-resistant tracing paper, bordered with protected edges → ❹ and stored in drawers. Ink drawings are made on transparent paper and water-resistant paper is used for paintings or diagrams. Fix the paper on a simple drawing board (designed for standard formats) made of limewood or poplar, using drawing pins with conical points → ❺. First turn over 2 cm of the paper's edge (later to be used as a filing edge – see p. 4): this lifts the T-square a little during drawing and prevents the T-square from smudging the work. (For the same reason, draw from top to bottom!) The drawing can be fixed with drafting tape rather than drawing pins → ❻ (which means that the drawing underlay can be made of plastic – Cellon or a similar smooth material). Drafting machines are common in engineering disciplines → ❻. In addition to simple parallel rules, there are also special versions with built-in protractors for setting angles; these are ruled with centimetre and octametre divisions → ❼. Other drawing aids feature pocket scale sets, parallel scale for hatching, division of lengths → ❽.

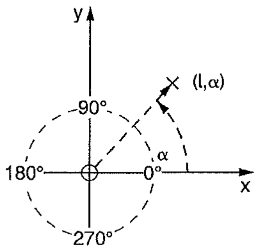
BS EN ISO 8560
BS 6750
DIN 4172

DRAWINGS
Paper formats
Technical drawings
Layout of drawings
Construction drawings
Construction drawing symbols
Water supply and drainage symbols
Electrical installation symbols
Security installation symbols
Gas installation symbols
Drawing by hand
Computer-aided drawing

BS EN ISO 13567
ISO 13567



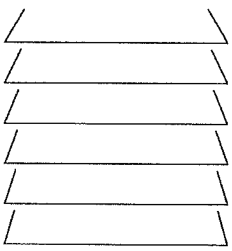
❶ Cartesian coordinate system. All points are defined through their x and y coordinates. The zero point can be set for each drawing or related to world coordinates.



❷ Polar coordinate system. All points are defined through their distance l from the zero point and the angle α related to the x-axis.

Measurement system	Abbr.	1 mm =	1 unit
point	pt	2.8346 pt	0.3528 mm
inch	in″	0.0394″	25.4 mm

❸ Conversion factors for common computer units



❹ Structuring of a CAD drawing by arranging groups of similar objects on their own layers

Obligatory					–	Facultative					–	Obligatory							
W	h	o			W	h	e	r	e			W	h	a	t				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Who-where-what naming of layers with variable field sizes (according to CadForum). The layer names have suitable abbreviations containing 2 or 3 pieces of information, each separated by an underscore. The content should be clear from the first 20 characters, because some CAD systems restrict the layer names to this length. Special characters should be avoided in order to prevent exchange problems.

Who (1–5) = author

possible abbreviations for authors
Arch = Architect
IArch = Interior architect
LArch = Landscape architect
BIng = Building engineer
Ei = Electrical engineer
St = Structural engineer
HLS = Heating/ventilation/sanitary
Geom = Surveyor

Where (7–11) = categorisation

possible categories
BS = basement
GR = ground floor
FL1 = 1st floor
EL_N = north elevation
SEC_A = section A-A

What (13–20) = description

possible descriptions
axes
structure
openings
finishings
furniture
hatching

dimensioning
labelling
drawing outline

examples of layer names

Arch_GR_axes
Arch_GR_structure
Arch_GR_finishes
Arch_GR_hatching

on smaller projects, the 2nd category (facultative) can be left out:
Geom_level curves
Arch_structure
BIng_openings

❺ Example of naming layers with variable, understandable labels

Drawings

Drawings are always an abstraction of reality because they are in two dimensions. The degree of abstraction depends on the content and, above all, on the intended purpose of the drawing. The lowest degree of abstraction is represented by perspectives, collages and renderings, which attempt to come quite close to reality. In order to produce the desired impression, it is particularly important to leave some free rein for the fantasy of the viewer. Diagrams can be used to explain functional interactions. Working drawings contain all the required information about dimensions, materials and arrangement of the object to be produced. In this case, all details must be unambiguous and comprehensible for the producer, and therefore have a high degree of abstraction.

In the age of computer-generated images, it still remains important to have a command of the rules and regulations of traditional drawing → pp. 39–40.

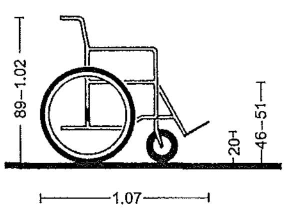
Computer-aided drawings

Drawing with a computer is very different from the classic methods of drawing on paper. There are two basic principles: raster graphics, in which every pixel of a drawing is saved (image processing), and vector graphics, where the start, end and the properties of a drawing element are saved (CAD). Because the output appears on a monitor screen or plot, there are also problems representing bodies and rooms in two dimensions. Only very simple CAD programs work with two-dimensional data models. More common are three-dimensional data models (object-oriented programs), which produce the desired type of illustration on output (monitor, plotting). The information required for this is stored in a database in the computer. This enables the elements of a drawing (line type, line thickness and colour) to be linked to further information, which is not visible, e.g. which layer they belong to, dependence on other objects, material properties, manufacturing information, order numbers etc. These properties can be exploited for the structuring of content or for further use (e.g. tenders or cost estimation).

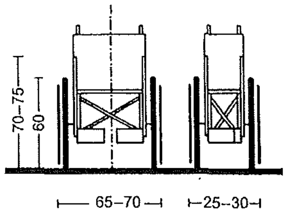
Volume modules permit further simulations. Structural, acoustic, climatic or lighting investigations can make precise statements about a building through the use of the appropriate software. 3D scanners, CNC machines and 3D plotters also enable the input and output of three-dimensional objects.

Data exchange

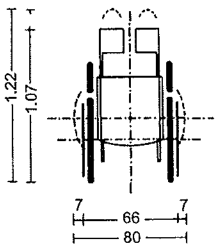
Because data is normally processed by a number of operators (various specialist technicians and engineers), a unified, understandable and clear system of organisation is important. When selecting a CAD system or deciding the working methods, it is important to know that all future processors of the data will work with the same software, or which interfaces can be used to exchange data. Exchange formats usually have a limited range of structuring possibilities and therefore organisation categories, which are not supported, will be lost or have to be recreated, with the associated waste of time. The naming of layers is governed by ISO 13567, which, however, uses cryptic abbreviations. It seems more practical to use the more flexible and easily understood naming system published by the specialist magazine CadForum → ❺.



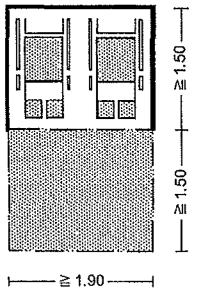
❶ Standard wheelchair, side elevation



❷ Front elevation, folded



❸ Plan



❹ Space requirement for wheelchair parking space and movement area

General design basics

Building regulations cover the design, construction and furnishing of housing, of accessible public buildings or parts of buildings, of workplaces and their external spaces. These buildings must be accessible for all people free of barriers. The users must be in a position to be almost completely independent of outside help. This applies notably to wheelchair users, the blind and visually impaired, those with other disabilities, old people, children and those of exceptionally short or tall stature.

Movement areas

Are those necessary for moving a wheelchair and are to be designed according to the minimum space requirement of a wheelchair user. The wheelchair → ❶ – ❹ and the movement area for the person → ❾ – ⓬ provide the modules for this. The dimensions of the movement area are 0.90–1.80 m and may overlap – except in front of lift doors. A depth and width of at least 1.50 m should be provided in every room for turning. (More information on movement areas is found on the following pages.)

ACCESSIBLE BUILDING

Dimensions for wheelchair users

Accessible public buildings

Accessible housing

BS 8300

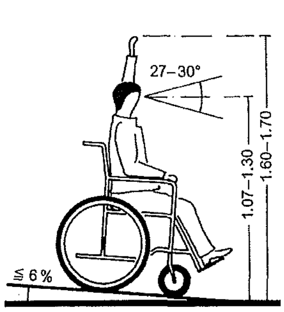
DD 266

DIN 18024

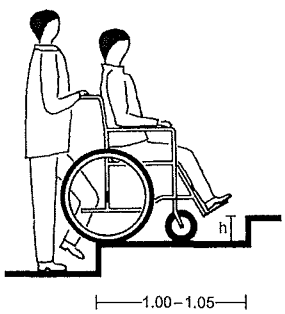
DIN 18025

MBO

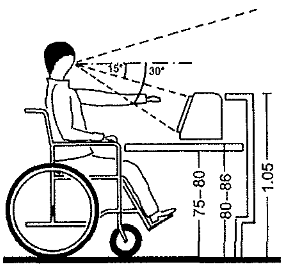
see also: Lifts pp. 128–134



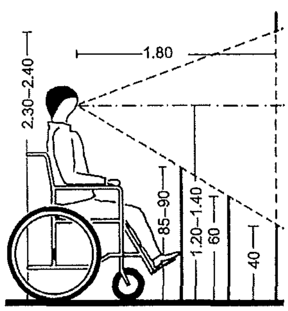
❺ Wheelchair on slope



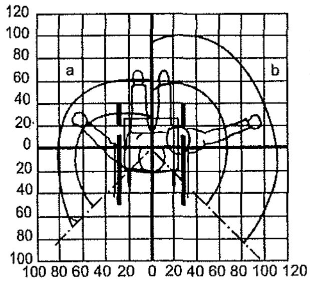
❻ On stairs



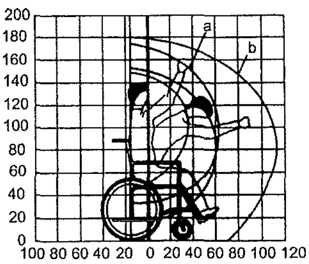
❼ Computer workplace



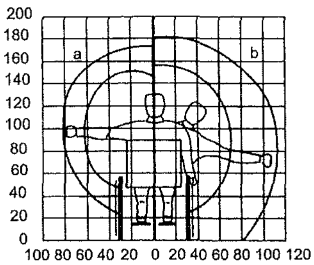
❽ At a window



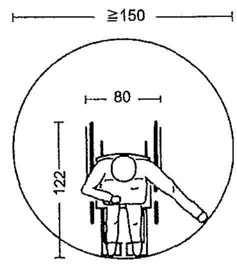
❾ On a plan



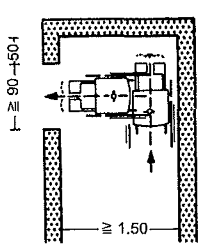
❿ From the side



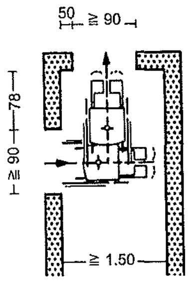
⓫ From behind



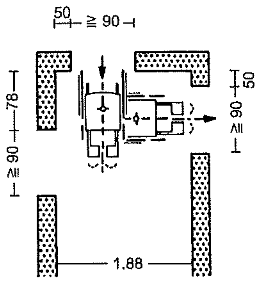
⓬ Minimum turning space



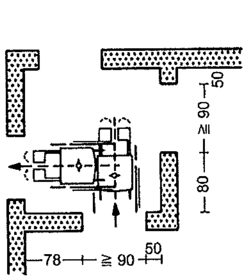
⓭ Passage through one door



⓮ Through two doors

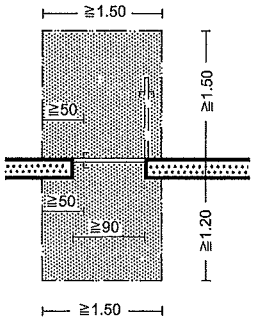


⓯ With three doors

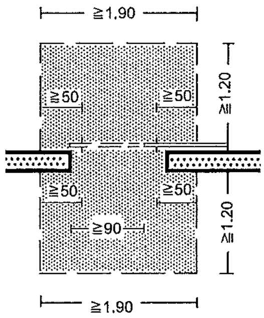


⓰ With four doors

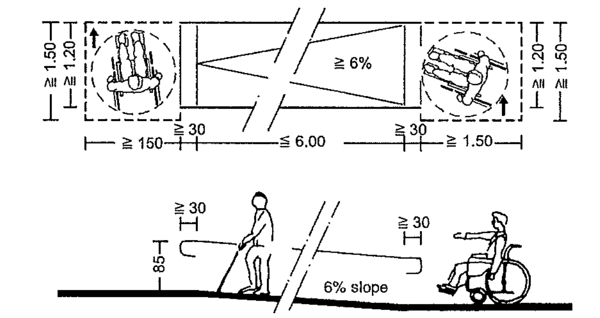
see also: Lifts 128–134



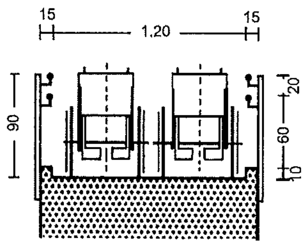
❶ Movement areas in front of hand-operated side-hung doors



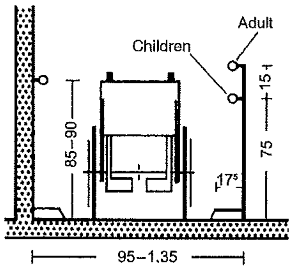
❷ Movement areas in front of hand-operated sliding doors



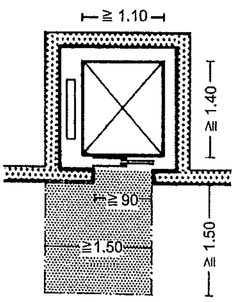
❸ Ramp



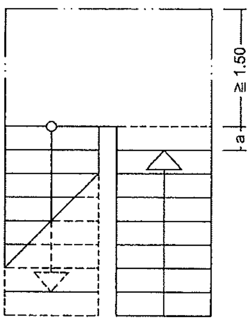
❹ Ramp in section



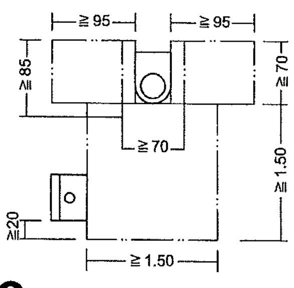
❺ Dimensions of corridors and passages



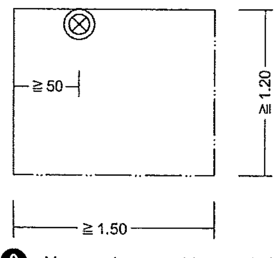
❻ Plan, with clear dimensions of the lift car and movement area in front of the doors



❼ Movement area in front of stairs going up and down



❽ Overlapping of movement areas in sanitary facilities



❾ Movement area next to operated facility

ACCESSIBLE BUILDING

Accessible Public Buildings

Movement areas must be:

min. 1.50 m wide and min. 1.50 m deep…
in every room as a place to turn, at the start and end of ramps, in front of telephone boxes, public telephones, service counters, passages, pay desks, checkpoints, post boxes, automatic service machines, calling/speaking equipment.

min. 1.50 m wide …
in corridors, main routes and next to stairs up and down.

min. 1.50 m deep …
in front of therapy facilities (e.g. bath, couch), in front of wheelchair parking places, next to the long side of the vehicle of a wheelchair user in car parks → p. 23 ❿.

min. 1.20 m wide …
alongside facilities which a wheelchair user has to approach from the side, between the wheel kerbs of a ramp and next to operated equipment.

min. 0.90 m wide …
in access ways next to cash desks and checkpoints and on side routes.

Accessibility without steps
All levels of buildings designed in accordance with the principles of accessibility must be accessible without steps, i.e. using a lift or a ramp.

Lifts
Cars of lifts must have a min. clear width of 1.10 m and a clear depth of 1.40 m. The movement area in front of the doors must be as large as the floor area of the car, but min. 1.50 m wide and 1.50 m deep → ❻. This area must not overlap with other traffic routes and movement areas.

Ramps
May have a maximum slope of 6% → ❸. If ramps are longer than 6 m, an intermediate landing of min. 1.50 m length is required. The ramp and the intermediate landing are both to be provided with 10 cm high wheel kerbs and handrails (diameter 3–4.5 cm) at a height of 85 cm. The clear ramp width must be min. 1.20 m. Wheel kerbs and handrails must project 30 cm horizontally into the platform area. There must be no stairs down in the extension of the ramp.

Stairs. The movement area next to the stairs going up and down must be min. 1.50 m wide; the tread of the first step is not to be included in the calculation of the movement area → ❼.

Doors
Clear passage width of doors ≧0.90 m → ❶ + ❷. Doors to toilets, showers and changing rooms must open outward.

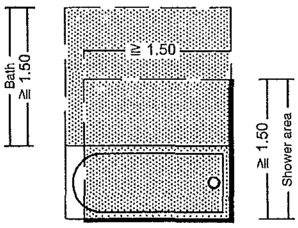
Sanitary facilities
At least one toilet must be provided for wheelchair users in all sanitary facilities. The seat height should be 48 cm → ❽.

Corridors and meeting areas
Corridors and routes longer than 15 m must have a passing place for two wheelchair users of at least 1.80 m width and depth.

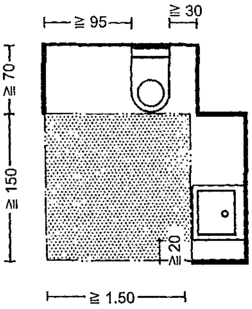
Wheelchair parking place
A wheelchair parking place for each wheelchair user is to be included in the design, preferably in the entrance area. Space requirement and movement area → p. 21 ❹.

BS 8300
DD 266
DIN 18024
DIN 18025

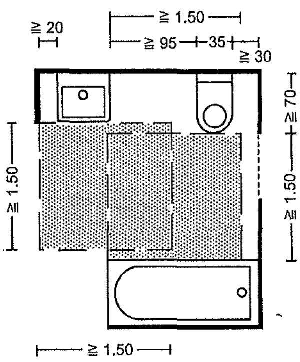
MBO



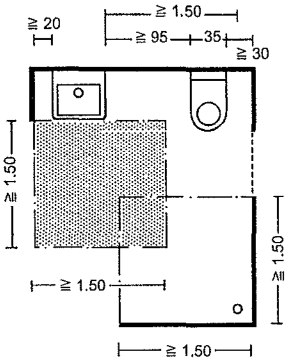
❶ Movement area by shower; alternative – bath



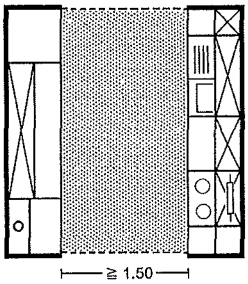
❷ Movement area in front of and next to WC and washbasin



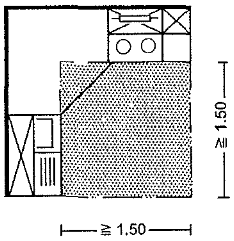
❸ Overlapping of movement areas in bathroom (with bath)



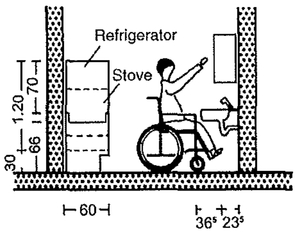
❹ Overlapping of movement areas in bathroom (with shower)



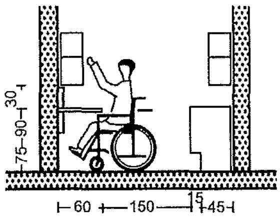
❺ Movement area in a double-space kitchen



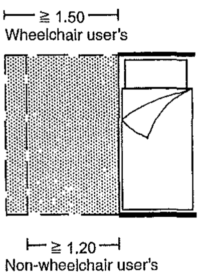
❻ Movement area in an L-layout kitchen



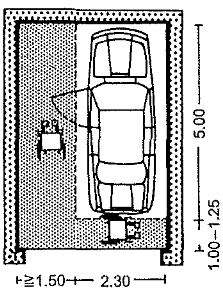
❼ Dimensions at the sink, stove and refrigerator



❽ Dimensions in the kitchen



❾ Space requirement at the long side of a wheelchair user's and non-wheelchair user's bed



❿ Space requirement in a garage

Movement areas which must be:

min. 1.50 m wide and min. 1.50 m deep...
a turning place in every room (excepting small rooms, which the wheelchair user can use by moving backwards and forwards), the shower → ❶ + ❹, in front of the WC and vanity unit → ❷ – ❹, in an outside seating area, in front of lift shaft doors, at the start and end of a ramp and in front of the intake of a rubbish chute.

min. 1.50 m deep...
in front of the long side of a wheelchair user's bed → ❾, in front of cupboards, in front of kitchen installations → ❺ – ❽, in front of the access side of a bath → ❶ + ❸, in front of a wheelchair parking place and in front of the long side of a vehicle → ❿.

min. 1.50 m wide...
between walls outside the house, next to steps going up and down, where the tread of the uppermost step is not to be included in the movement area.

min. 1.20 m wide...
along furniture which the wheelchair user approaches from the side, along the access side of a non-wheelchair user's bed → ❾, between walls within the dwelling, next to operated equipment → p. 22 ❾, between wheel kerbs of a ramp → p. 22 ❸ and on routes within a house.

Accessibility without steps
All rooms belonging to a dwelling and the communal facilities of a house must either be without steps, or have a lift → p. 22 ❻, or be accessible with a ramp → p. 22 ❸. Door stops and thresholds at the bottom of doors should be avoided, but if absolutely necessary may not be higher than 2 cm.

Wheelchair parking place
A wheelchair parking place is to be included in the design for each wheelchair user, preferably located in the entrance area, for transferring from street to indoor wheelchair. Space requirement and movement area → p. 22 ❾.

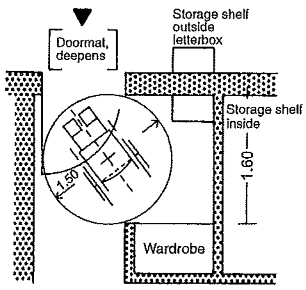
Bathroom
The bathroom is to be provided with a wheelchair-accessible shower. The later installation of a bath should be possible near the shower. The movement area to the right or left of the WC must be at least 95 cm wide and 70 cm deep. From one side of the WC towards the wall, or furniture, there must be a distance of min. 30 cm → ❷ – ❹. No bathroom doors may open inwards.

Kitchen
The main items of equipment items like the refrigerator, stove and sink, plus the worktop, are to be arranged as close as possible to each other. It must be possible for a wheelchair to pass under the sink and worktop without limitation. For the sink, this means that either a waste fitting behind the plaster or a flat fitting on the surface is necessary. Shelf space must be accessible for the wheelchair user and no tall units should be included in the design. The horizontal reach area is about 60 cm, and the vertical activity range is 40–140 cm. The optimum height of the worktop (approx. 75–90 cm) should be discussed with the disabled person and fixed at a height to suit the user → ❼ + ❽.

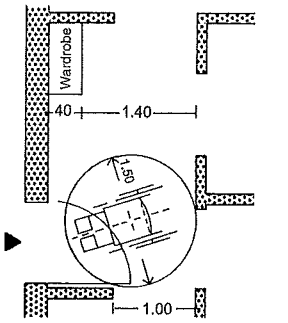
Car parking place
A weather-protected car parking place or garage is to be provided for each dwelling. A movement area of 1.50 m depth should be provided next to the long side of the car → ❿.

ACCESSIBLE BUILDING

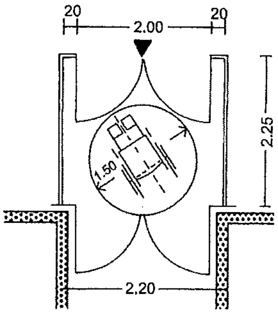
Accessible Housing



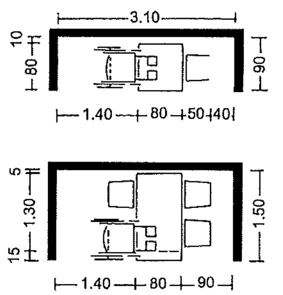
❶ Deep entrance area with coat rack



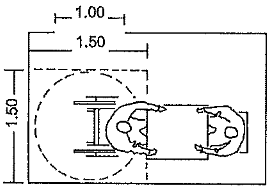
❷ Transverse layout of entrance area



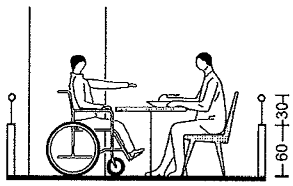
❸ Entrance lobby with double-leaf door



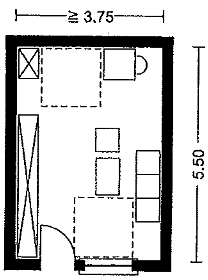
❹ Dining area layout for two or four people



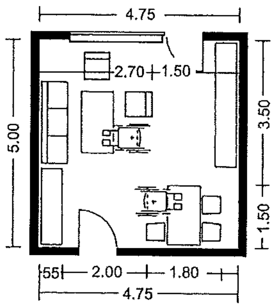
❺ Plan of open-air seating area



❻ Elevation of open-air seating area



❼ Living room for 1–2 people



❽ Living room with dining area for 4–5 people (23.75 m²)

Housing suitable for wheelchairs

Wheelchair users must be able to travel into all the rooms of a dwelling, and into all rooms available to the residents of a house in common, and to use all facilities. The wheelchair user must be in a position to be mostly independent of outside help. This applies notably to the blind and visually impaired, the deaf and hearing-impaired, the physically disabled, old people, children and people of exceptionally short or tall stature.

In order to turn 180°, a wheelchair user requires at least 1.50 m² → ❶ + ❷. This space requirement determines the size of, and movement area in, corridors, rooms, garages etc. In residential apartment blocks, access through corridors or hallways is the most frequent arrangement. In this case, angles and corners are to be avoided as far as possible; a straight access corridor is suitable. The minimum area of an entrance hall should be 1.50 × 1.50 m, and an entrance lobby with a single-leaf door 1.70 × 1.60 m. A window with a clear view from a parapet height of 60 cm should be provided in at least one living room of a dwelling. An entry phone at the flat or house door is an important item of equipment for a blind resident.

Living area

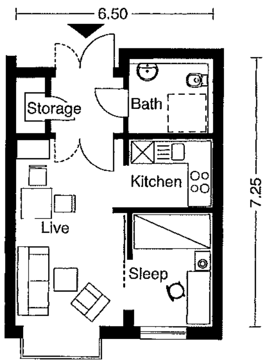
Adequate freedom of movement for wheelchair users is important in living rooms. There should also be room for at least two further wheelchair users as visitors. For a living room with an eating area, the minimum floor area should be: in a flat for one person 22 m², for 2–4 people 24 m², for five people 26 m² and for six people 28 m²; minimum room width 3.75 m (1–2 person household).

Open-air seating area

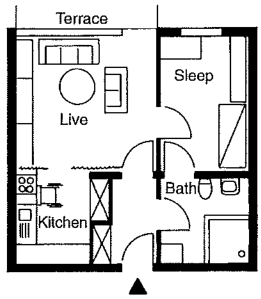
Every dwelling should be provided with an open-air seating area such as a terrace, loggia or balcony with a min. size 4.5 m². The movement area must be min. 1.50 m wide and 1.50 m deep → ❺.

Additional living space

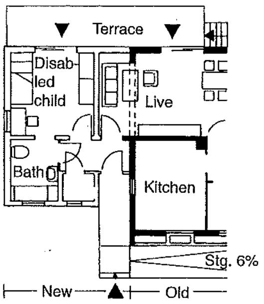
Additional living space should be provided for every wheelchair user if required. The floor area of a flat is normally increased by about 15 m² by this requirement.



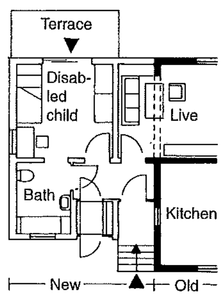
❾ Single-room flat for wheelchair user (40–45 m²)



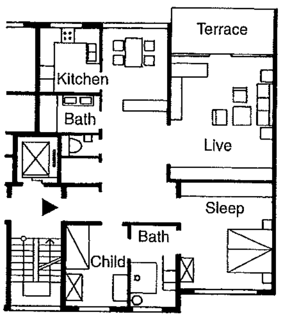
❿ Two-room flat (50–55 m²)



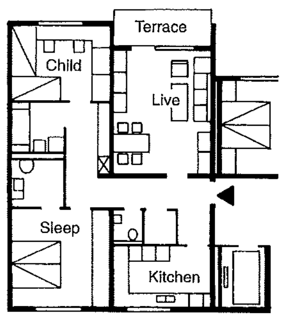
⓫ Accessible extension to two-family house; ramp to overcome level difference



⓬ Installation of an accessible vertical lift



⓭ Accessible flat for three people in a block with two flats per floor

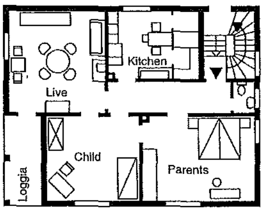


⓮ Accessible flat for four people in a block with three flats per floor

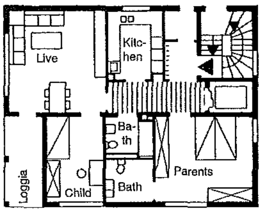
ACCESSIBLE BUILDING
Dimensions for wheelchair users
Accessible public buildings
Accessible housing

BS 8300
DD266
DIN 18024
DIN 18025

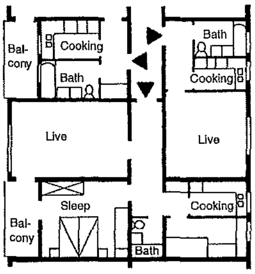
MBO



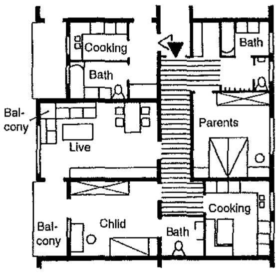
❶ Flat in two-family house before conversion → ❷



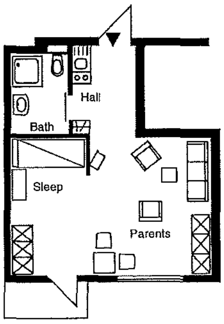
❷ Flat in two-family house after conversion for serious disability



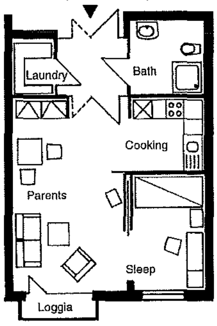
❸ 2½ living room and 1 bedroom flat before conversion → ❹



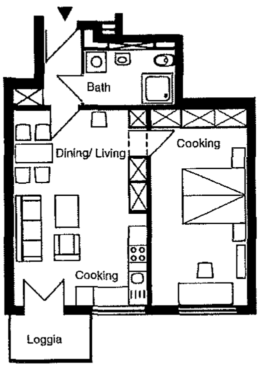
❹ One living room and two bedroom flat after conversion (for a visually impaired child)



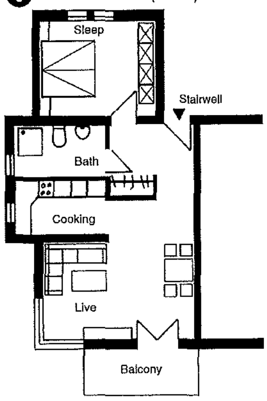
❺ One-room flat (40 m²)



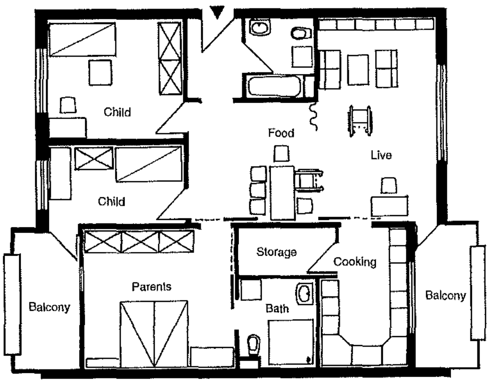
❻ One-room flat (45 m²)



❼ Two-room flat (54 m²)



❽ Flat (60 m²)



❿ Four-room flat (110 m²)

Accessible building

(§ 50 of MBO – Model Building Regulations – applied at state level)

(1) In buildings with more than two flats, the flats on one floor must be accessible. In these flats, the living rooms and bedrooms, one toilet, one bathroom and the kitchen or kitchenette must be accessible with a wheelchair.

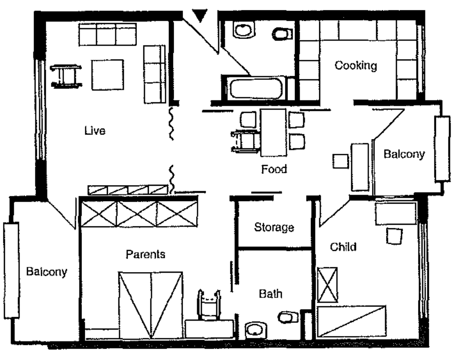
(2) Buildings which are publicly accessible, must in their parts serving the general public be capable of being accessed and used, according to their purpose, by disabled people, old people and people with small children, without outside help. This requirement applies notably to cultural, educational, sport, leisure and health facilities, offices, administration buildings and courts, sales and catering establishments, parking, garages and toilets.

(3) Buildings, according to (2), must be accessible through an entrance with a clear opening width of at least 0.90 m without steps. An adequate movement area must be available in front of doors. Ramps may not have a slope of more than 6%, must be at least 1.20 m wide and have a fixed handrail with a safe grip on both sides. A landing is to be provided at the start and end of the ramp and also an intermediate landing every 6 m. The landings must have a length of at least 1.50 m. Stairs must have handrails on both sides, which are to be continued past landings and window openings and past the last steps. The stairs must have solid risers. Corridors and entrance halls must be at least 1.50 m wide. One toilet must also be suitable and accessible for wheelchair users; this is to be indicated by a sign.

(4) Sections 1–3 do not apply if the installations can only be fulfilled with unreasonable expense on account of difficult terrain conditions, the installation of an otherwise unnecessary lift, unsuitable existing buildings or the safety of disabled or old people.

	1 person	2 people	3 people
living room	20.0	20.0	22.0
dining area	6.0	6.0	10.0
bedroom	16.0	24.0	16.0
child (1 bed)	–	–	14.0
bathroom	6.0	7.0	7.0
kitchen	8.0	9.0	9.0
corridor	5.0	6.0	6.0
storage room	1.0	1.0	1.5
storage (E-wheelchair)	6.0	6.0	6.0
spare room (washing machine)	1.0	1.0	1.0
living area	**69.0**	**80.0**	**98.5**

❾ Guideline sizes for flats with one wheelchair user – living area in m² [determination of requirements www.nullbarriere.de]



⓫ Three-room flat (95 m²)

DIMENSIONAL BASICS AND RELATIONSHIPS
Man as measure and purpose
The universal standard
Body measurements and space requirements
Geometrical relationships
Dimensions in building

Throughout history human beings have created things to be of service to them, using measurements relating to their bodies. Until relatively recent times people's limbs were the basis for all the **units of measurement.** Even today we can still have a better idea of the size of an object if it is compared to humans or their limbs: it was so many men high, so many ells (arm lengths) long, so many feet wider or so many heads bigger. These are expressions that we are born with: it could be said that their sizes are in our nature. But the introduction of the **metre** brought all that to an end.

We should therefore attempt to achieve the most precise and vivid possible idea of this unit. Building clients do the same when they measure out the rooms of their properties in order to envisage the dimensions shown on the drawings. Anyone who intends to learn how to build should start by visualising the size of rooms and objects as clearly as possible, and constantly practise, so that every line they draw and every stated dimension of yet to be designed furniture, rooms or buildings can appear as an image before their eyes.

We do, however, immediately have an accurate idea of the scale of an object when we see a **person** beside it, whether in the flesh or as an illustration. It is a poor reflection on our times that our trade and professional journals only too often depict rooms or buildings without any people in them. Such pictures can often create a false impression of the scale of a building and it is often astonishing how different they look in reality – mostly much smaller. This contributes to the frequent lack of cohesive relationships between buildings, because their designers have worked to various arbitrary scales and not to the only proper scale, human beings.

If this is to be changed, then **architects and designers** must be shown where these haphazard dimensions, mostly accepted without thought, originated. They must understand the relationships of the size of the limbs of a healthy human being and how much space a person occupies in various postures and in movement. They must also be familiar with the dimensions of the **appliances,** clothing etc. which people encounter every day, in order to be able to determine the appropriate sizes for containers and furniture. They must know how much **space** a person needs between furniture in the kitchen, dining room, libraries etc. in order to undertake the necessary reaching and working among these fittings in comfort without squandering space. They must know how **furniture** should be placed so that people can fulfil their tasks or relax in the home, office or workshop. And, finally, the architect and designer need to know the minimum practical dimensions of spaces in which people move around on a daily basis, like trains, trams, vehicles etc. These typically very restricted minimum spaces give the designer fixed impressions, which are then used, even if unintentionally, to derive dimensions of other spaces.

The human being, however, is not just a living creature that needs space. The **emotional response** is no less important. The way a room is dimensioned, divided, painted, lit, entered and furnished has great significance for the impression it makes. Starting from all these considerations and insights, I set out in 1926 to collect, in an organised way, the experience gained from a wide variety of professional practice and teaching.

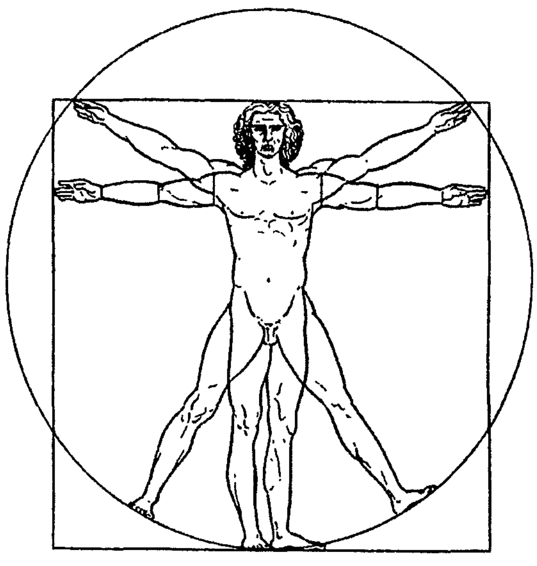
The present data book was developed from this work, starting from the human being and providing the framework for assessing the dimensions of buildings and their constituent parts. This involved, for the first time, the investigation, development and comparison of many fundamental questions.

Current technical options have been included here to the greatest possible extent. Account is taken of common **standards.** Description is often reduced to the absolute minimum and supplemented or even replaced with illustrations wherever feasible. This should provide the creative architect or designer, in methodically ordered, brief and coherent form, the necessary information which would otherwise have to be laboriously extracted from countless books or researched circuitously by surveying existing buildings. Great value has been placed on the restriction of the content to a digest of the fundamental data and experience, with the inclusion of completed buildings only where they seemed necessary as general examples.

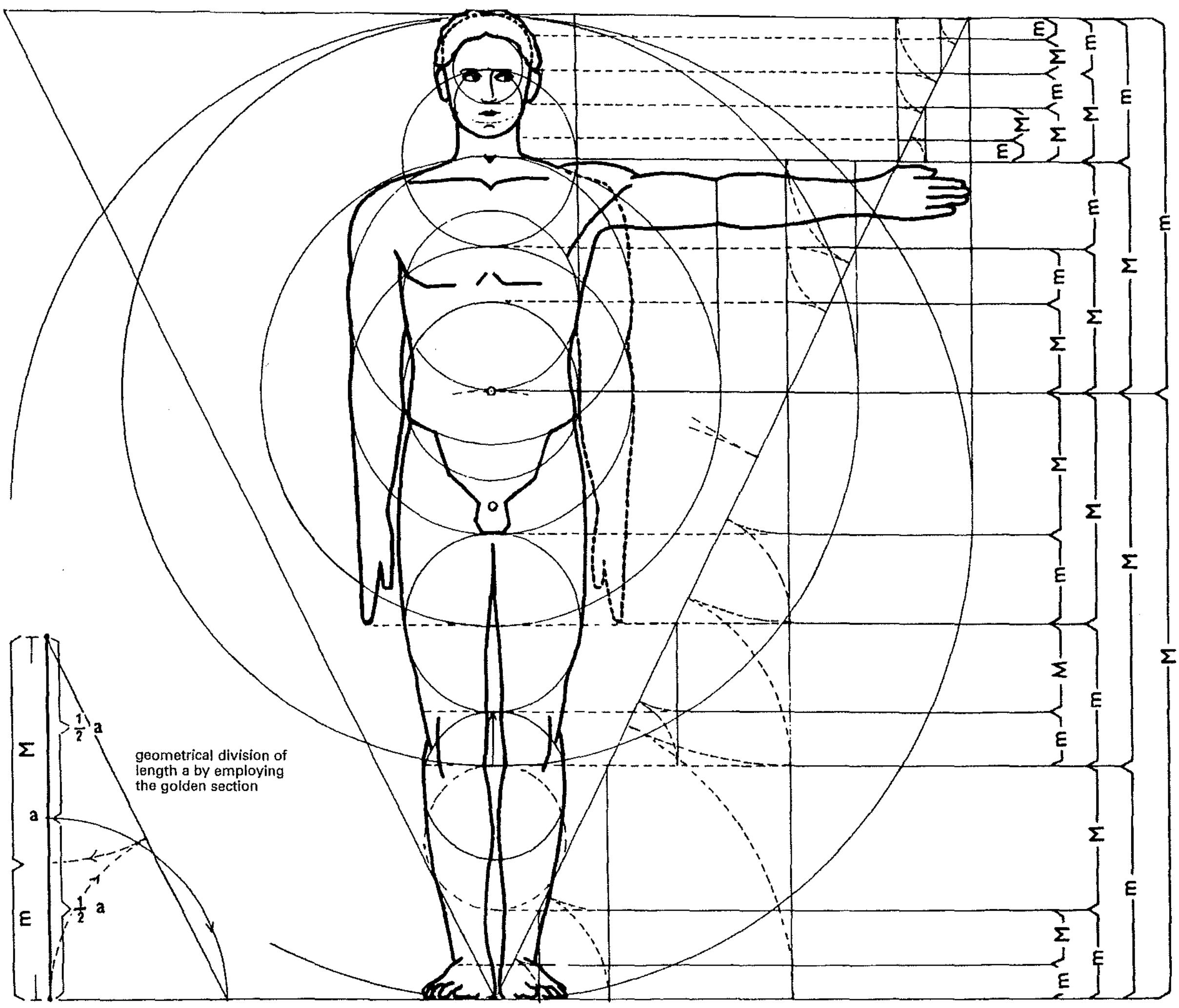
By and large, of course, each building commission is different and (apart, of course, from adherence to relevant standards) should be studied, approached and designed anew by the architect. Completed projects can much too easily tempt us to imitate, or at least establish conventions, which the architect entrusted with a similar task can often escape only with difficulty. If, however, as is intended here, creative architects are given only the tools, then this compels independent thinking so that they weave all the components of the current commission into their own imaginative and unified construction.

Finally, the tools presented here have not been collected more or less randomly from some journal or other, but systematically sought out in the literature as the data required for each building task. They have been checked against well-known examples of similar buildings and, where necessary, data has also been acquired through models and experiments. This was always with the intention of saving the practising architect or designer the effort of these basic investigations, so that sufficient time and leisure can be devoted to the important creative aspects of the commission.

Ernst Neufert



1 Leonardo da Vinci: Rules of Proportion



Man's dimensional relationships
The oldest known canon describing the dimensional relationships of the human being was discovered in a burial chamber among the pyramids near Memphis (about 3000 BCE). Certainly, since then, scientists and artists have been engaged in trying to decipher human proportional relationships. We know about the proportional systems of the Egyptian pharaohs, of the time of Ptolemy, of the ancient Greeks and Romans, and the Canon of Polykleitos, which was long considered the standard, plus the work of the Middle Ages and of Alberti, Leonardo da Vinci, Michelangelo and, above all, Dürer's world-famous advances.

In all these systems, the human body was measured according to lengths of head, face or foot, which were than later sub-divided and related to each other so that they were applicable in everyday life. Even into our own times, the foot and the ell (arm's length) have remained common measures. In particular, the details worked out by Dürer became a common standard. He started from the height (h) of a human being and expressed the sub-divisions as fractions:

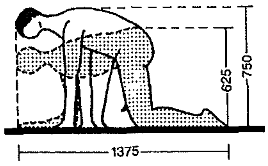
$1/2$ h = the entire torso from the crotch upwards
$1/4$ h = leg length from ankle to knee, length from chin to navel
$1/6$ h = foot length
$1/8$ h = head length from hair parting to underside of chin, spacing of nipples
$1/10$ h = face height and width (including ears), hand length to the wrist,
$1/12$ h = face width at level of underside of nose, leg width (above the ankle) etc.
The sub-divisions extend to $1/40$ h.

In the last century, A. Zeising achieved greater clarity than anyone on this subject with his investigations of the dimensional relationships of man's proportions. He made exact measurements and comparisons based on the golden section → p. 33. Unfortunately, this work did not earn appropriate recognition until recently, when E. Moessel, an important researcher in this area, endorsed Zeising's work with detailed examinations using his methods.

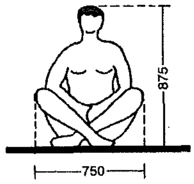
From 1945, Le Corbusier also used, for all his projects, the sectional relationships of the golden ratio, which he called 'Le Modulor'. His measures were human height = 1.829 m; navel height = 1.130 m etc. → p. 33.

DIMENSIONAL BASICS AND RELATION-SHIPS

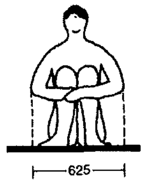
Man as measure and purpose
The universal standard
Body measurements and space requirements
Geometrical relationships
Dimensions in building



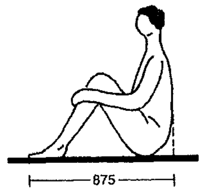
❶ Crawling



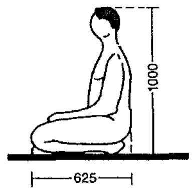
❷ Sitting cross-legged



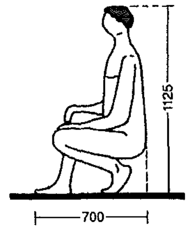
❸ Sitting (from the front)



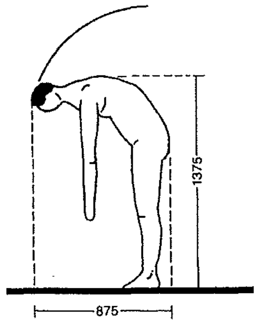
❹ Sitting (from the side)



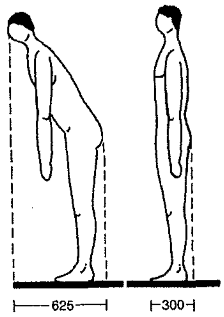
❺ Kneeling



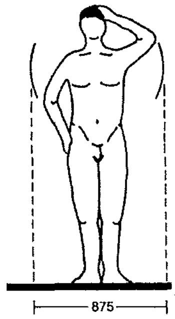
❻ Squatting



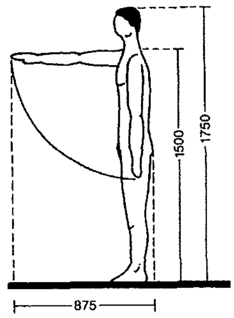
❼ Bending over



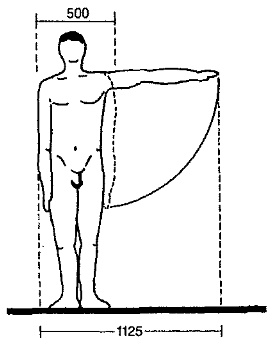
❽ Standing leaning forward, standing



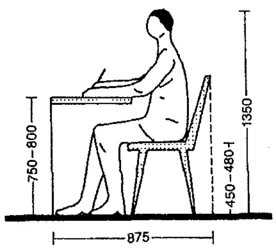
❾ In movement



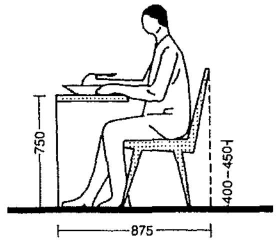
❿ Outstretched arm (forwards)



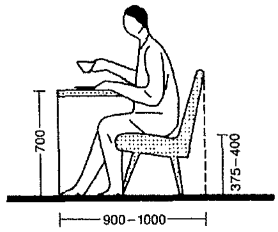
⓫ Outstretched arm (sideways)



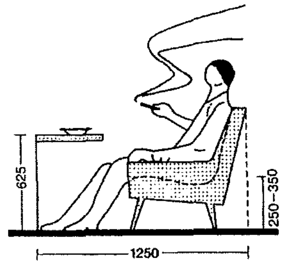
⓬ Dimensions: at the desk



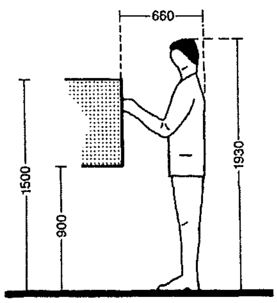
⓭ Dimensions: at the dining table



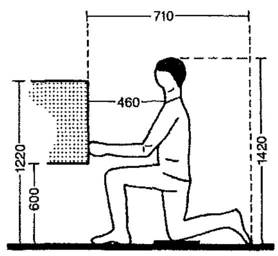
⓮ Dimensions: in a small easy chair



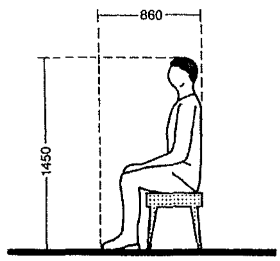
⓯ Dimensions: in an armchair



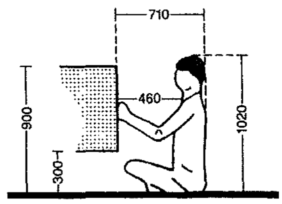
⓰ Working while standing



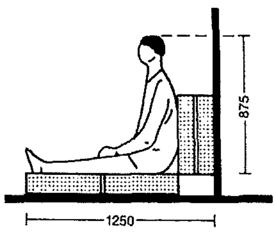
⓱ Kneeling



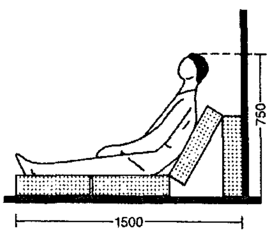
⓲ Sitting on a chair



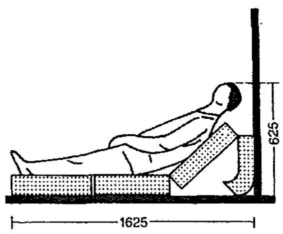
⓳ Sitting on the floor



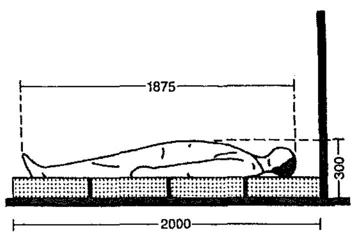
⓴ Sitting on a mattress



㉑ Leaning against sloping backrest



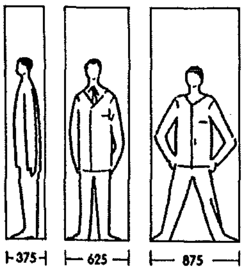
㉒ Lying with raised back



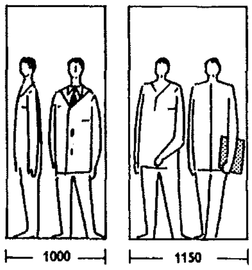
㉓ Lying

In accordance with normal measurements and energy consumption

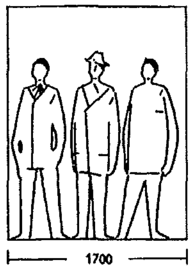
SPACE REQUIRED BETWEEN WALLS



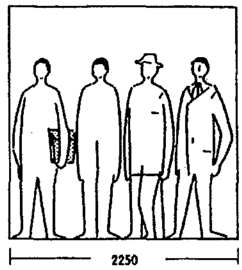
❶ Between walls (≧10% supplement for people moving)



❷ Two people next to each other

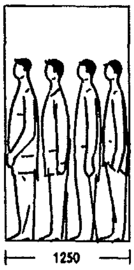


❸ Three people next to each other

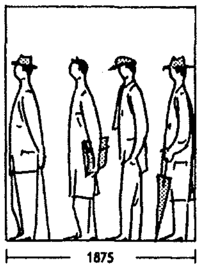


❹ Four people next to each other

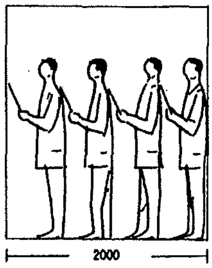
SPACE REQUIRED BY GROUPS



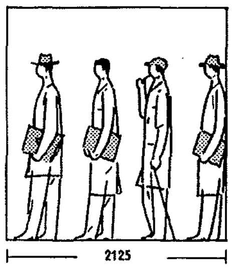
❺ Closely packed



❻ Normal spacing



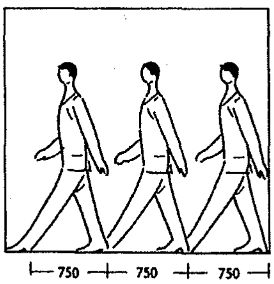
❼ Choir group



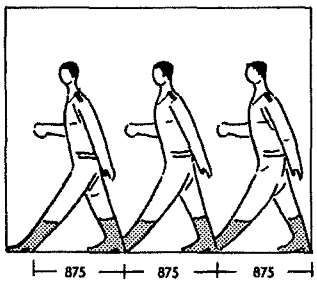
❽ Longer periods of standing

❾ With back packs

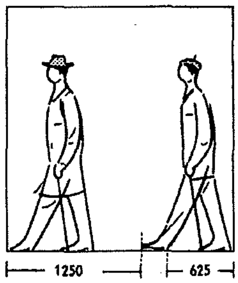
STEP LENGTHS



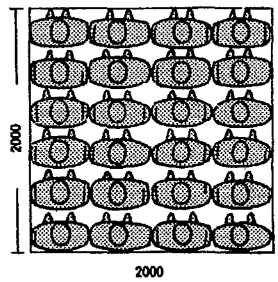
❿ Walking in step



⓫ Marching

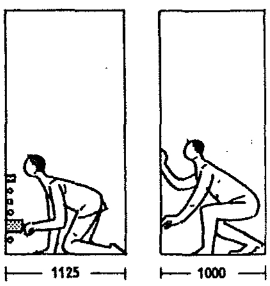


⓬ Strolling

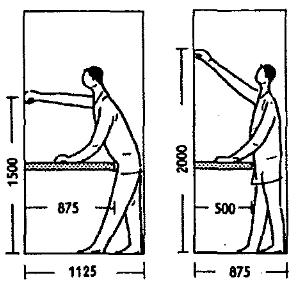


⓭ Max. no. people per m^2: 6 (e.g. cable car)

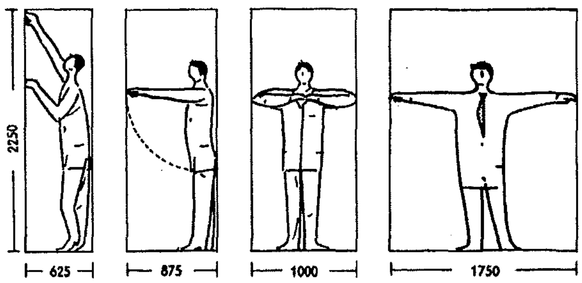
SPACE REQUIRED FOR VARIOUS BODY POSTURES



⓮ Kneeling

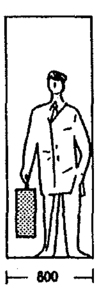


⓯ At the desk

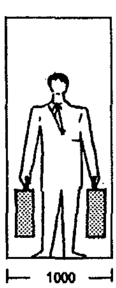


⓰ Stretching

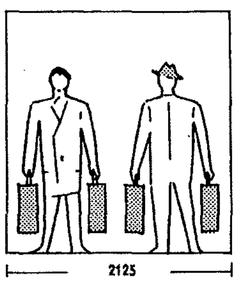
SPACE REQUIRED WITH HAND LUGGAGE



⓱ One suitcase



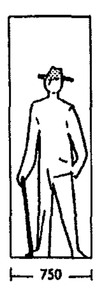
⓲ Two suitcases



⓳ Two people with two suitcases each

SPACE REQUIRED WITH WALKING STICK AND UMBRELLA

⓴ Handbag



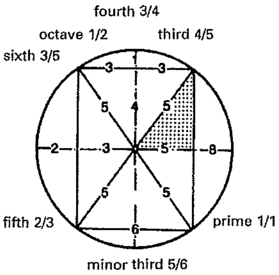
㉑ With walking stick

㉒ With umbrella

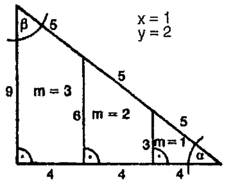
㉓ Two people with umbrellas

DIMENSIONAL BASICS AND RELATIONSHIPS

Geometrical Relationships



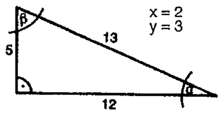
❶ Pythagorean rectangle includes all interval proportions but excludes the disharmonic seconds and sevenths



❷ Pythagorean triangle

α	a	b	c	β	m	x	y
36°87'	3	4	5	53°13'	1	1	2
22°62'	5	12	13	67°38'	1	2	3
16°26'	7	24	25	73°74'	1	3	4
28°07'	8	15	17	61°93'	0.5	3	5
12°68'	9	40	41	77°32'	1	4	5
18°92'	12	35	37	71°08'	0.5	5	7
43°60'	20	21	29	46°40'	0.5	3	7
31°89'	28	45	53	58°11'	0.5	5	9

❸ Number relationships from Pythagorean equations (selection)



❹ Example

There have been agreements about the dimensioning of buildings since early times. The first specific statements date from the time of Pythagoras, who started from the basis that the numerical proportions found in acoustics must also be optically harmonic. This led to the development of the **Pythagorean rectangle** → ❶, which contains all the harmonic interval proportions but not the two disharmonic intervals – the second and seventh.

Spatial measurements can be derived from these number relationships. Pythagorean or diophantic equations produce number groups ❷ – ❹, which should be used for the width, height and length of rooms:

$a^2 + b^2 = c^2$
$a = m\,(y^2 - x^2)$
$b = m \times 2 \times x \times y$
$c = m\,(y^2 + x^2)$

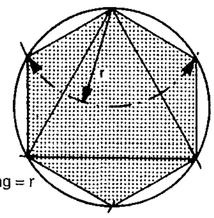
Where **x, y** are whole numbers, **x** is less than **y, m** is the magnification or reduction factor.

The geometric shapes named by Plato and Vitruvius are also of critical importance: **circle, triangle** → ❺ and **square** → ❻, from which **polygonal traverses** can be constructed. Each halving then gives further polygonal traverses. Other polygonal traverses (e.g. heptagon → ❾, nonagon → ❿) can be formed only by approximation or by superimposition. For example, a 15-sided polygon → ❽ can be constructed by superimposing an equilateral triangle onto a pentagon.

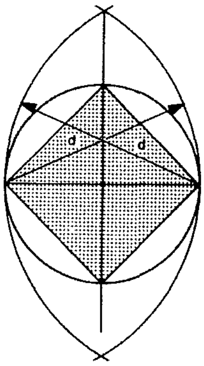
The pentagon → ❼ or **pentagram** has a natural relationship to the golden section, as does the derived decagon, but in earlier times its particular dimensional relationships were hardly ever used → p. 32 ❶ – ❸.

Polygonal traverses are necessary for the design and construction of so-called 'round' buildings.

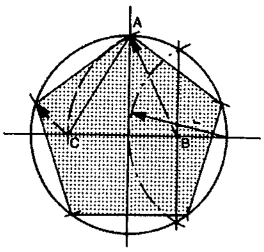
The determination of the most important measurements – radius r, chord c and height of a triangle h – is shown in → ⓭ – ⓮ → p. 32.



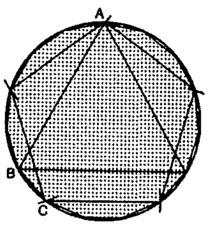
❺ Equilateral triangle, hexagon



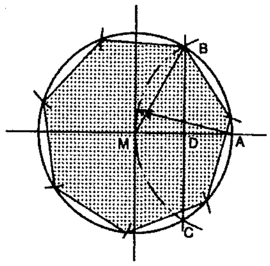
❻ Square



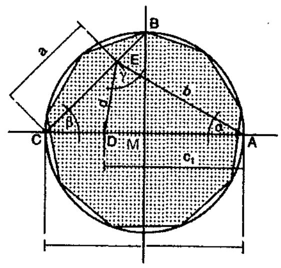
❼ Pentagon: bisection of the radius gives point B; an arc with centre B and radius AB gives point C; distance AC equals the side of a pentagon



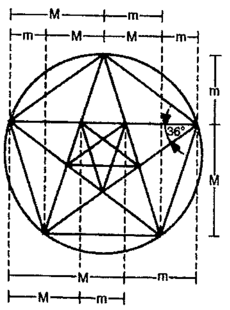
❽ 15-sided polygon
$AC = \frac{2}{5} - \frac{1}{3} = \frac{1}{16}$



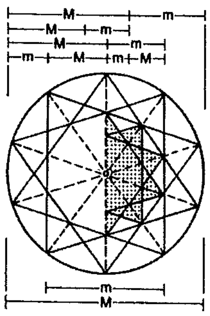
❾ Approximated heptagon: line BC halves line AM at D. Distance BD is approx. 1/7 of circumference



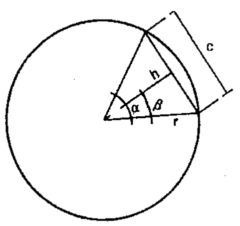
❿ Approximated nonagon: arc centred on A with radius AB gives point D on line AC. Arc centred on C with radius CM gives point E on arc BD. Distance DE is approx. 1/9 of circumference



⓫ Pentagon and golden section



⓬ Decagon and golden section



⓭ Calculation of dimensions in a polygonal traverse → p. 34

$h = r \cdot \cos\beta$

$\frac{s}{2} = r \cdot \sin\beta$

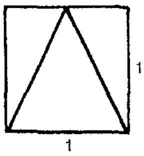
$s = 2 \cdot r \cdot \sin\beta$

$h = \frac{s}{2} \cdot \text{cotang}\,\beta$

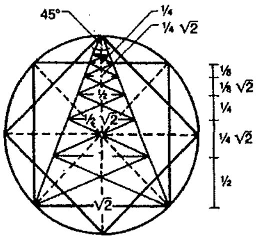
⓮ Formula → ⓭

DIMENSIONAL BASICS AND RELATION-SHIPS
Man as measure and purpose
The universal standard
Body measurements and space requirements
Geometrical relationships
Dimensions in building

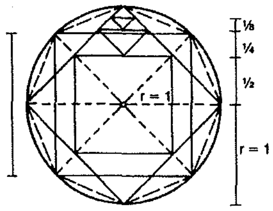
❶ Right-angled isosceles triangle: can be used for quadrature



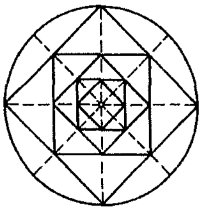
❷ Triangle (base = height)



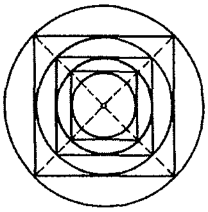
❸ π/4 triangle (A. v. Drach)



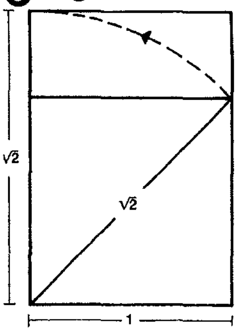
❹ Squares developed from the octagon → ❹ – ❻



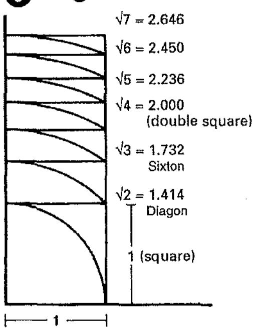
❺ → ❹



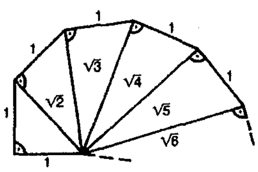
❻ → ❹



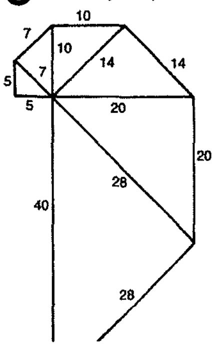
❼ 1:√2 rectangle



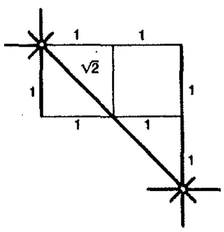
❽ Hierarchy of square roots



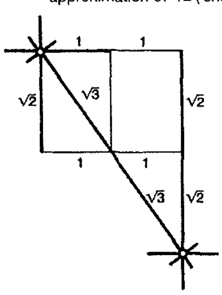
❾ Relationship between square roots



❿ Related numbers as approximation of √2 ('snail')



⓫ Examples of non-rectangular coordination → p. 34 MERO space frames: based on √2 and √3



⓬ √3

DIMENSIONAL BASICS AND RELATIONSHIPS

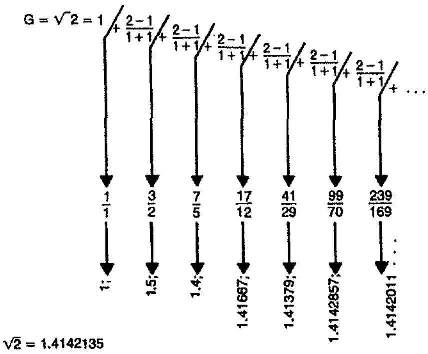
A right-angled isosceles **triangle** (two sides of equal length), with a relationship of baseline to height of 2:1, can be used for **quadrature** (the process of constructing a square of equal area to a given shape) → ❶. An isosceles triangle with the base and height forming two sides of a square was used successfully by the master cathedral builder Knauth to determine the dimensional relationships of the cathedral in Strasbourg → ❷.

The π/4 triangle of A. v. Drach → ❸ is rather more pointed than that described above because its height is determined by the point of the slewed square. It was used successfully by its inventor for details and devices.

The investigations of L. R. Spitzenpfeil into a number of old buildings have discovered octagonal relationships. These are based on the so-called **diagonal triangle**, where the height of the triangle is the diagonal of the square constructed over half of the base → ❹ – ❻. The sides of the rectangle formed from the diagonal triangle → ❼ have a ratio of 1:√2, so all halving or doubling of the rectangle produces the same ratio of 1:√2. This was used as the basis for the **ISO A series paper formats** → p. 4. Geometrical progressions in this relationship are produced by the hierarchies inside an octagon → ❹ – ❻ and the hierarchy of the square roots of numbers 1–7 → ❽.

The relationship between the square roots of whole numbers is shown in → ❾. The factorisation procedure permits the application of square roots for the installation of non-rectangular building elements. Building from approximated values for square numbers, Mengeringhausen developed the **MERO space frame.** The principle is the so-called 'snail' → ❿ – ⓬. The imprecision of the right angle is compensated by the screw connections of the rods at the nodes. A different approximate calculation of the square roots of whole numbers √n for non-rectangular building elements is offered by continued fractions (→ p. 33) according to the formula:

$$G = \sqrt{n} = 1 + \frac{n-1}{1+G} \rightarrow ⓭.$$



1	1	1	1
0.5	2	3	1.5
0.6	5	7	1.4
0.58333 ...	12	17	1.41667 ...
0.58621 ...	29	41	1.41379 ...
0.5857143 ...	70	99	1.4142857 ...
0.5857989 ...	169	239	1.4142011 ...
0.5857865 ...		√2	1.4142135 ...

⓭ Continued fractions of √2

DIMENSIONAL BASICS AND RELATIONSHIPS

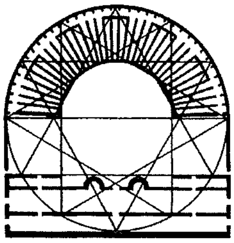
Geometrical Relationships

The use of geometrical and dimensional relationships based on the previous information was described by Vitruvius: according to his investigations, the Roman theatre, for example, is based on a triangle rotated four times → ❶, and the Greek theatre on a square rotated three times → ❷. Both constructions result in a dodecagon, which is recognisable on the stairs.

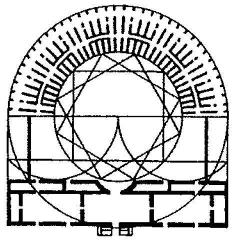
Moessel claims to have verified dimensional relationships according to the golden ratio, although this is unlikely → ❹. The only Greek theatre based on a pentagon is in Epidaurus → ❸. The design principle of the **golden** (holy, divine) **section** (ratio, mean) was applied in a Roman residential quarter excavated in Ostia Antica, the ancient harbour of Rome → ❺ – ❽. This principle is based on the bisection of the diagonals of a square. If the points at which the arcs (radius $\sqrt{2}/2$) intersect the sides of the square are joined up, this produces a nine-part grid. Its centre is the square of the golden section. The arc **AB** is with up to 0.65% deviation the same length as the diagonal **CD** of the original halved square. The golden section therefore represents an approximate method for squaring the circle. The entire complex at Ostia, from layout to fitting out details, was based on this ratio.

Palladio, in his four books on architecture, provides a geometrical key based on the work of Pythagoras. He used the same spatial relationships (circle, triangle, square etc.) and harmonies for his buildings → ❾ – ❿.

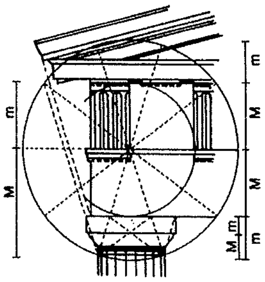
Similar laws of proportion are also expressed in clear rules by the ancient cultures of the East. The Indians with their 'Manasara', the Chinese with their modulation according to the 'Toukou', and above all the Japanese with their 'Kiwariho' methods created building systems which ensure traditional development and offer immense economic advantages → ⓫.



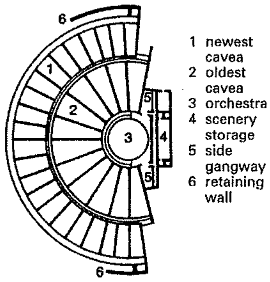
❶ Roman theatre (according to Vitruvius)



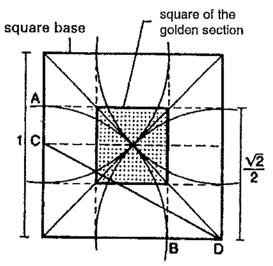
❷ Greek theatre (according to Vitruvius)



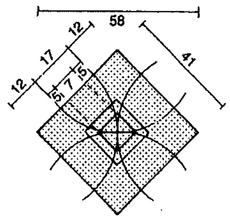
❸ Gable corner of a Doric temple: dimensional relationships based on the golden section



❹ Theatre in Epidaurus

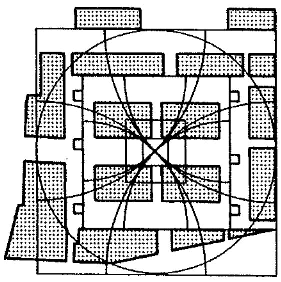


❺ Golden section, buildings in Ostia Antica

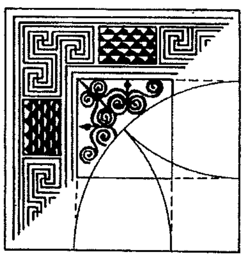


y	x	y/x ($\sqrt{2}$ = 1.4142...)
1	1	1
3	2	1.5
7	5	1.4
17	12	1.4166...
41	29	1.4137...

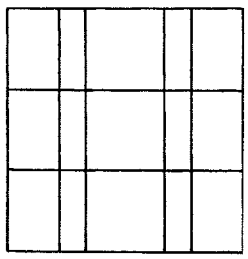
❻ Dimensional relationships of the golden section



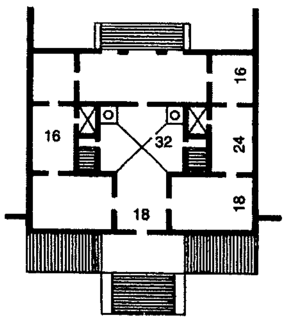
❼ Plan of the entire quarter



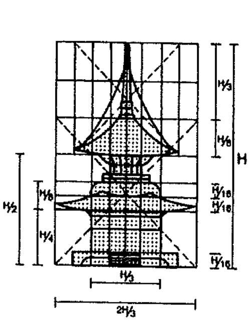
❽ Floor mosaic in a house in Ostia Antica



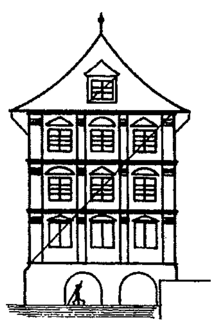
❾ Geometrical key to Palladio's villas



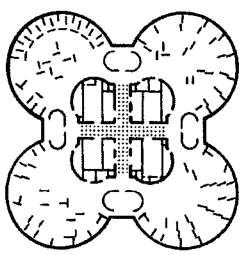
❿ Palladio, Villa Pisani in Bagnolo



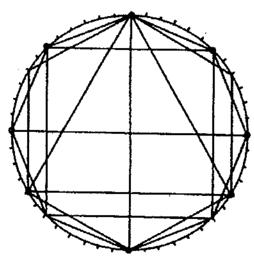
⓫ Japanese treasury



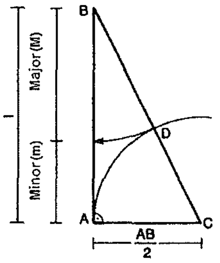
⓬ Rügen guildhall in Zürich



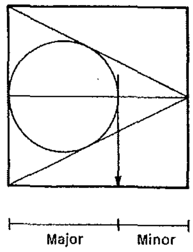
⓭ Plan of the BMW Administration Building in Munich



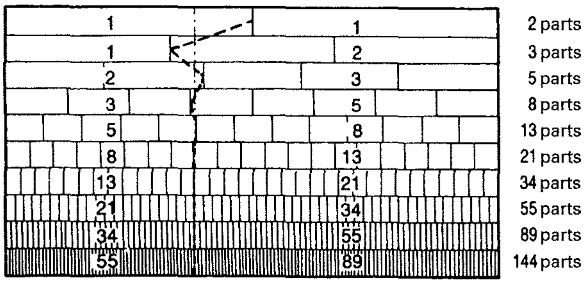
⓮ 48-sided polygon developed from a triangle → ⓭



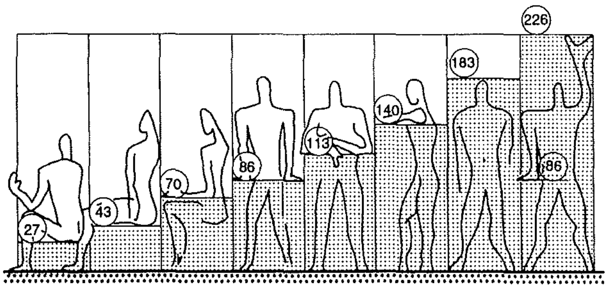
❶ Geometric construction of the golden section



❷ Relationship between square, circle and triangle



❸ Continued fraction: golden section



❹ Unlimited values

Values expressed in the metric system			
Red series		Blue series	
Centimetre	Metre	Centimetre	Metre
95280.7	952.80		
58886.7	588.86	117773.5	1177.73
36394.0	363.94	72788.0	727.88
22492.7	224.92	44985.5	449.85
13901.3	139.01	27802.5	278.02
8591.4	85.91	17182.9	171.83
5309.8	53.10	10619.6	106.19
3281.6	32.81	6563.3	65.63
2028.2	20.28	4056.3	40.56
1253.5	12.53	2506.9	25.07
774.7	7.74	1549.4	15.49
478.8	4.79	957.6	9.57
295.9	2.96	591.8	5.92
182.9	1.83	365.8	3.66
113.0	1.13	226.0	2.26
69.8	0.70	139.7	1.40
43.2	0.43	86.3	0.86
26.7	0.26	53.4	0.53
16.5	0.16	33.0	0.33
10.2	0.10	20.4	0.20
6.8	0.06	7.8	0.08
2.4	0.02	4.8	0.04
1.5	0.01	3.0	0.03
0.9		1.8	0.01
0.6		1.1	
etc.		etc.	

❺ Illustration of the values and sets of the Modulor, according to Le Corbusier

The golden section

The 'golden section' means that a length l is divided so that the ratio of the entire length to the larger part is the same as the ratio of the larger part to the smaller part. The golden section of a length can be determined either geometrically or by using a formula:

For the geometrical construction, the distance l (to be divided) is drawn as a vertical **AB** and the horizontal line **AC** (= AB/2) as the baseline of a right-angled triangle. The length of the baseline **AC** is transferred using a compass with centre **C** onto the hypotenuse **BC** of this triangle, thus dividing the hypotenuse into the parts **BD** and **DC**. The distance **BD** is the major part **M** of the vertical **AB**. This distance **M** is then transferred onto the vertical **AB**, thus dividing **AB** into a major part (M) and a minor part (m) → ❶.

Therefore: $\dfrac{\mathbf{l}}{\mathbf{major}} = \dfrac{\mathbf{major}}{\mathbf{minor}}$

The connection between the golden section and the proportions of square, circle and triangle is shown in → ❷. The golden sectioning of the distance can also be determined with the continued fraction

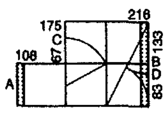
$$G = 1 + \frac{1}{G}$$

This is the simplest infinite regular continued fraction → ❸.

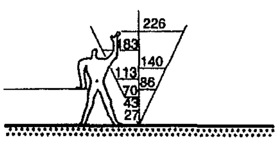
The Modulor

The architect Le Corbusier developed a theory of proportion based on the golden section and the dimensions of the human body. He marked out three intervals in the human body, which formed what Fibonacci named a golden section series: between **the foot, the solar plexus, the head, the fingers of the raised hand.** Le Corbusier first assumed 1.75 m to be the average height of a European, and divided this, according to the golden section, into the dimensions 108.2 – 66.8 – 41.45 – 25.4 cm → ❽.

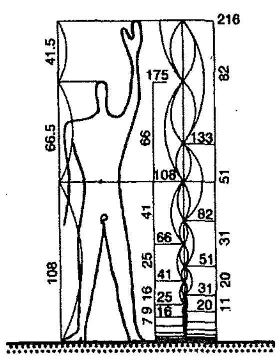
Because this last dimension is almost exactly 10 in, Le Corbusier found a connection with the English inch, but this did not apply to the larger dimensions. Consequently he later altered his average body height to 6 English feet (= 1.828 m) and from there developed, according to the golden section, the so-called **red series** upwards and downwards → ❺. Because the steps in this series were too large for practical use, he then developed an additional **blue series**, starting from 2.26 m (fingertips of the raised hand), with double the values in the red series → ❺. The values in the red and blue series were then implemented by Le Corbusier as practical measurements → ❹.



❻ unit A = 108
double B = 216
extension of A = C = 175
shortening of B = D = 83

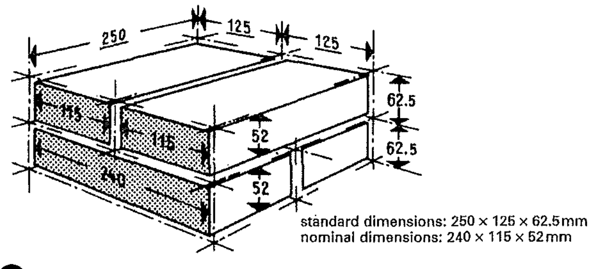


❼ The Modulor

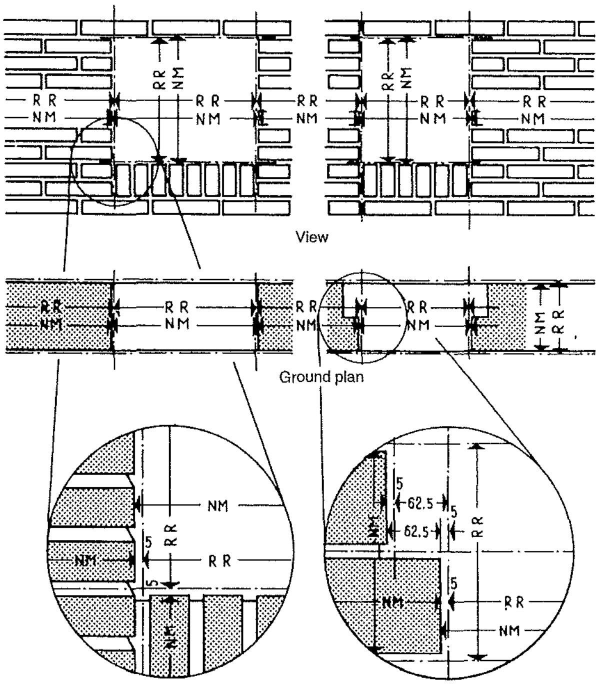


❽ Proportional figure

BS 6750
BS EN ISO 8560
BS 2045
DIN 323
DIN 4172



❶ Nominal and standard size of continental European wall bricks



❷ Modular structural dimensions (RR) and nominal dimensions (NM) for brickwork

Terms

Building preferred numbers are those for modular construction dimensions and the individual, structural and finished dimensions derived from them.

Modular dimensions are only theoretical dimensions, but are the basis for the individual, structural and finished dimensions used in practice. Structural dimensions or nominal dimensions (for construction types with joints and wall finishes) are derived from modular dimensions by deducting or adding the component for the joint or the finish thickness. (Example: modular dimension for the length of a brick = 25 cm; thickness of the vertical joint = 1 cm; nominal dimension for the length of the brick = 24 cm; modular dimension for the thickness of poured concrete walls = nominal dimension = 25 cm).

Individual dimensions are dimensions (mostly small) for units of structure or finishing such as joint thicknesses, plaster thicknesses, door rebate sizes, wall projection sizes, tolerances.

Structural dimensions are of the unfinished structure, such as masonry dimensions (without plaster thicknesses), structural slab thicknesses, sizes of unplastered door and window openings.

Finished dimensions are for the finished building, such as clear sizes of plastered rooms and openings, storage space dimensions, floor-to-floor heights.

Nominal dimensions are the same as modular dimensions for building types without joints. For building types with joints, the nominal dimension is the modular dimension less the joint thicknesses.

Small dimensions are 2.5 cm and less. They can be selected from the sizes: 2.5 cm; 2 cm; 1.6 cm; 1.25 cm; 1 cm; 8 mm; 6.3 mm; 5 mm; 3.2 mm; 2.5 mm; 2 mm; 1.6 mm; 1.25 mm; 1 mm.

DIMENSIONAL BASICS AND RELATIONSHIPS

Dimensions in Building

Preferred numbers

Preferred numbers have been introduced for the standardised sizing of machinery and technical devices. The starting point is the continental unit of length the metre (→ 40 in). The engineering requirement for geometrical graduation made the purely decimal division of the metre impractical. The geometrical 10-part preferred number series is therefore: **1; 2; 4; 8; 16; 31.5; 63; 125; 250; 500; 1000**. These are formed from the **halving series** (1000, 500, 250, 125) and the **doubling series** (1, 2, 4, 8, 16); the doubling number 32 was rounded down to 31.5 towards the exact value of the halving number (31.25), and the halving number 62.5 was rounded up to 63. The larger 5-part and the finer 20- and 40-part series fit in accordingly with their intermediate numbers.

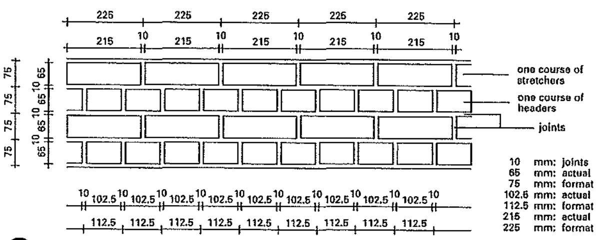
Preferred numbers offer many advantages for calculation: products and quotients of any number of preferred numbers are themselves preferred numbers, whole-number percentages of preferred numbers are again preferred numbers, and doubled and halved preferred numbers also remain preferred numbers.

Although there is scarcely a need for geometrical graduation in building (considering the predominantly arithmetical addition of similar elements like: blocks, joists, rafters, trusses, columns, windows and similar) the so-called **building preferred numbers** have been defined and laid down.

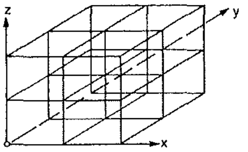
Brickwork dimensions in the UK differ: in the past large variations in the size of fired clay products often led to critical problems with bonding clay bricks. Now, BS 3921 provides one standard for dimensioning → ❶: coordinating size (225 × 112.5 × 75 mm, including 10 mm in each direction for joints and tolerances), and the relating work size (215 [2 headers plus 1 joint] × 102.5 × 65 mm).

Series preferred for the structure				Series preferred for individual dimensions	Series preferred for finishings			
a	b	c	d	e	f	g	h	i
25	25/2	25/3	25/4	25/10	5	2 × 5	4 × 5	5 × 5
				2.5				
				5	5			
			6¼	7.5				
		8⅓		10	10	10		
	12½			12.5				
			12½	15	15			
		16⅔		17.5				
			18¾	20	20	20	20	
				22.5				
	25	25	25	25	25			25
				27.5				
			31¼	30	30	30		
		33⅓		32.5⅔				
				35	35			
	37½		37½	37.5				
		41⅔		40	40	40	40	
			43¾	42.5				
				45	45			
50	50	50	50	50	50	50		50
				52.5				
			56¼	55	55			
		58⅓		57.5				
				60	60	60	60	
	62½		62½	62.5				
				65	65			
		66	68¾	67.5				
				70	70	70		
				72.5				
75	75	75	75	75	75			75
			81¼	80	80	80	80	
		83⅓		82.5				
				85	85			
	87½		87½	87.5				
		91⅔		90	90	90		
			93¾	92.5				
				95	95			
				97.5				
100	100	100	100	100	100	100	100	100

❸ Building preferred numbers

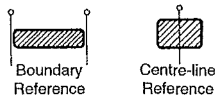


❹ Wall elevation illustrating brick sizes in the UK

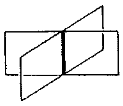


❷ Coordinate system

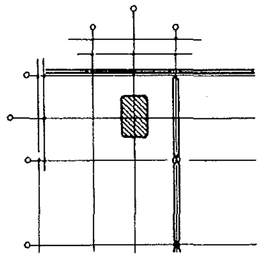
❶ Coordinate plane

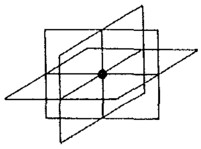


❸ Boundary reference, centre-line reference



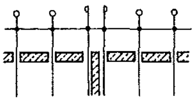
❹ Coordinate line (intersection of two planes)



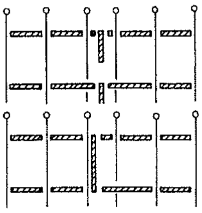


❺ Coordinate point (intersection of three planes)

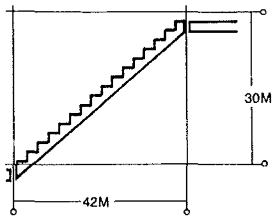
❻ Superimposed partial coordinate systems



❼ Non-modular zone

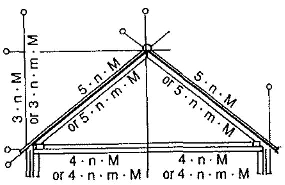


❽ Modular zone with laterally connected, non-modular building components

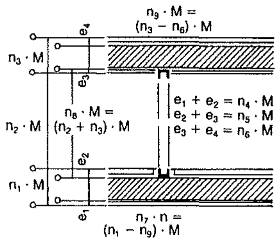


Storey height = 30 m
Flight length on plan 42 m
Selected:
16 risers 18.75/26.2 cm
(assuming/cm joints)

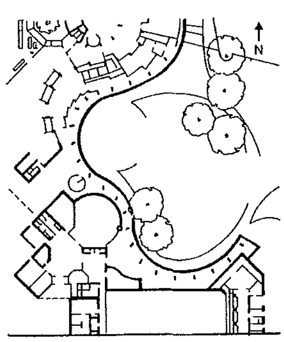
❾ Pre-cast reinforced concrete stair element



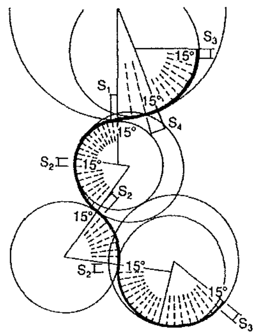
❿ Application example – sloping roof



⓫ Compensating measure on the verticals



⓬ Construction of a curving roof edge from regular polygon traverses (site plan)



⓭ Modular polygon traverse → ⓬

Modular coordination in building

The modular system is a means of coordinating the dimensions applicable to building work. The term 'coordination' is the key: a modular building standard contains details of a design and detailing system based on coordination as an aid in the design and construction of buildings. It gives geometrical and dimensional definitions for the spatial coordination of building components. It also enables technical areas, which depend on each other with regard to geometry and dimensions (e.g. building, electrical engineering, transport) to be connected.

Geometrical considerations

A coordinate system is always object-specific. It is used to coordinate building structures and components, and determine their position and size. From these are derived nominal dimensions of building components, plus joint and connection thicknesses → ❶ – ❺. A coordinate system consists of planes arranged at right angles to each other, spaced according to the coordinate measurements. Depending on the system, these can be of different sizes and in all three dimensions.

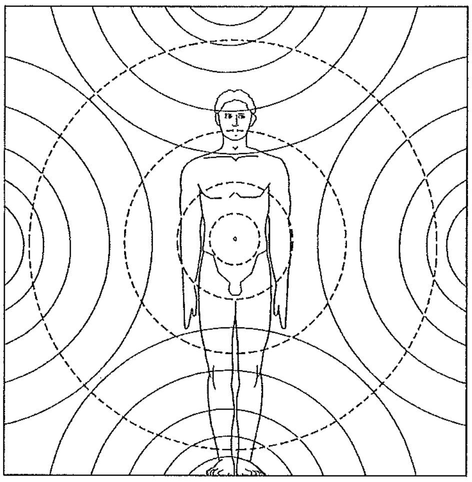
Building components are normally arranged in one dimension between two parallel coordinate planes so that they fill the coordinate dimension, including the joint component and also taking tolerances into account. A building component is therefore defined in its extent, i.e. its size and position, in one dimension. This is called **boundary reference** → ❸. In other cases, it can be advantageous not to position a building component between two planes but rather to have its centre-line coincide with a coordinate plane. The component is thus specified in one dimension, but only in terms of position. This is called **centre-line reference** → ❸. A coordinate system can be sub-divided into various sub-systems for different groups of building elements (e.g. load-bearing structures, space-demarcating components etc.) → ❻.

It has become apparent that not all individual components have to be modular (e.g. each step in a staircase, windows, doors, etc.), but only the building elements they are combined into (e.g. staircases, façade or partition elements etc.) → ❾. For non-modular building components which continue along or across the whole building, a **non-modular zone** can be introduced, which completely divides the coordinate system into two sub-systems. The precondition is that the size of the building component in the non-modular zone is already known at the time when the coordinate system is set out, because the non-modular zone can only have completely specified dimensions → ❼. Further ways of arranging non-modular building components are the so-called central position and edge position in modular zones → ❽.

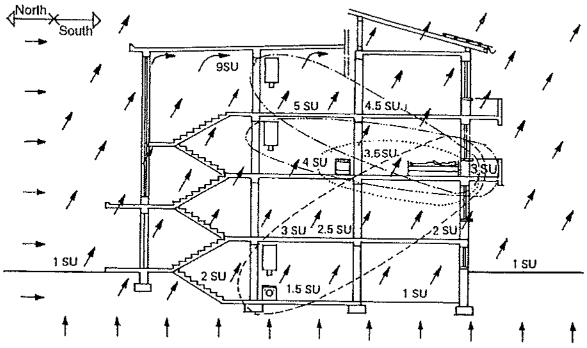
The units of the modular system are the **basic module M** = 100 mm and the **multi-modules** 3 M = 300 mm, 6 M = 600 mm and 12 M = 1200 mm. There are also standardised non-modular supplementary dimensions l = 25 mm, 50 mm and 75 mm for fitting elements or overlapping connections → ⓫. Combination rules can be used to fit building components of various sizes into a modular coordinate system.

Number groups (e.g. Pythagoras') or factorisation (e.g. continued fractions) can be utilised to fit non-rectangular building components into a modular coordinate → ❿. The construction of polygon traverses (e.g. triangle, square, pentagon and their halves) can be used to design so-called 'round' building structures → ⓬ – ⓭.

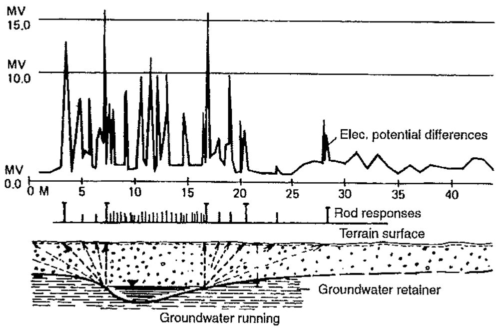
BS EN ISO 8560
BS 6750
DIN 18000



❶ Building biology as the study of the holistic interaction between building and resident



❷ Electromagnetic fields in and around a building



❸ Differences in electrical potential above a groundwater aquifer

electrical and magnetic fields ('electro-smog')	low-frequency alternating electrical fields through connected power cables, electrical devices etc. low-frequency alternating magnetic fields through switched-on electrical devices etc. high-frequency fields from mobile phone transmitters, telephone etc. static electricity from synthetic materials, wools etc. static magnetic fields
building material measurements	heavy metals, toxins, radiation
air pollutants	air pollution, toxins, gases, fine dust, allergens
noise/vibration	
earth radiation and earth magnetic field	geopathogenic disturbance zones (e.g. underground watercourses and 'earth rays')

❹ The extent of building biology measurements of the built environment (example)

BUILDING BIOLOGY
Basics

Building biology is a collective term for the study of the **holistic interaction between building and resident** → ❶ – ❷. Its aim is to determine any **deleterious effects** for the human organism through the consideration of physical, chemical and microbiological conditions in interiors and, if appropriate, take measures to relieve the causes (via 'healthy living'). The themes of building biology partially overlap with other disciplines: building ecology**,** whose main focus is the protection of nature and environment in the construction and operation of buildings and in the manufacture, processing and final disposal of building materials, building physics and electrical engineering as well as biology, chemistry and medicine.

The principles of building biology are especially suitable for application in residential building but also in the construction of schools, hospitals, kindergartens and offices.

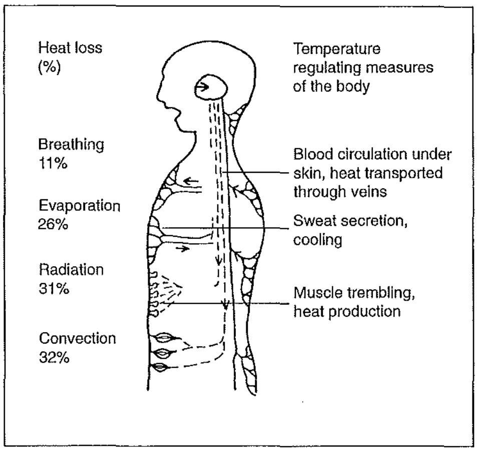
The fact that the people today spend 90% of their lives inside buildings and are surrounded to an increasing degree by electromagnetic fields has increased public interest in building biology in recent years. Meanwhile, 2–5% of the German population now suffer complaints (e.g. headaches, insomnia, tiredness and concentration problems) due to the presence of building biological pollution of their homes and offices.

The investigation of a building therefore normally includes the following areas:

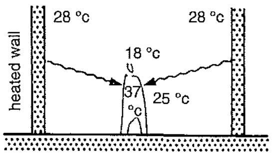
- measurement of **electric, magnetic and electromagnetic** fields from technical devices in the low- and high-frequency ranges
- testing of **building materials** for toxins, heavy metals and radiation
- testing of **rooms' air quality** for pollutants (toxins and gases, fibres, fine dust and allergens)
- microbiological investigations of **bacteria and mould formation,** and measurements of **noise, vibration and light** → ❹.

Measurements related to **radiaesthesia** ('radiation sensitivity') can also be carried out, in attempts to demonstrate geopathogenic disturbance zones (e.g. underground watercourses and 'earth rays') can be discovered using dowsing, pendulums and other alternative scientific methods → ❸.

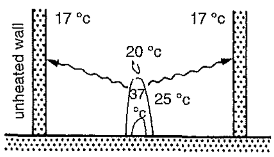
The term **'building biology'** is not yet officially regulated in Germany. This means that anyone can call themselves a building biologist independent of their level of education and practical experience. It is possible to discern two basic directions in the field of building biology. **Scientific-oriented** building biology attempts to use scientific methods to create healthy living and working conditions. Measurements must be carried out using scientifically recognised and reproducible methods, in order that harmful effects in buildings can be reliably detected and remedied. **Alternative-oriented** building biology assumes that the influences affecting people have so far been recognised scientifically only to a limited extent. The resulting measurements, and the theories and threshold values they are based on are therefore disputed, as there are sometimes no reliable methods for measuring such threshold values.



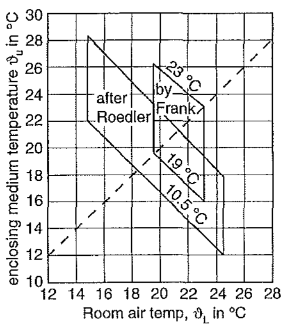
❶ Heat output and temperature-regulating measures of the human body



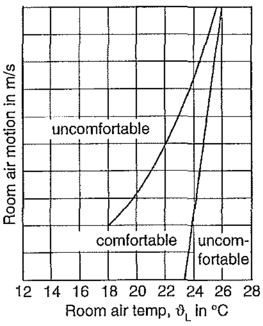
❷ Thermal comfort



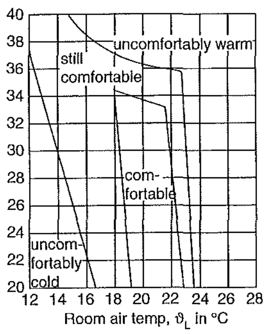
❸ Thermal discomfort



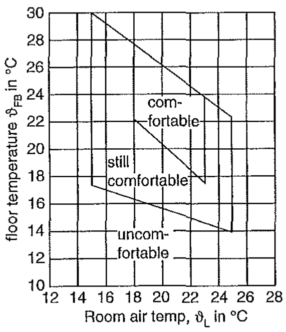
❹ Thermal comfort zone (temperature of surrounding surfaces and of air)



❺ Thermal comfort zone (room air movement and room air temperature)



❻ Thermal comfort zone (ceiling and room air temperature)



❼ Thermal comfort zone (floor and room air temperature)

Thermal comfort is experienced when the thermal circulation regulated by the body is in balance, i.e. the body can regulate warmth with as little effort as possible. This type of comfort is experienced when the heat produced by the body corresponds to the actual heat loss to the surroundings.

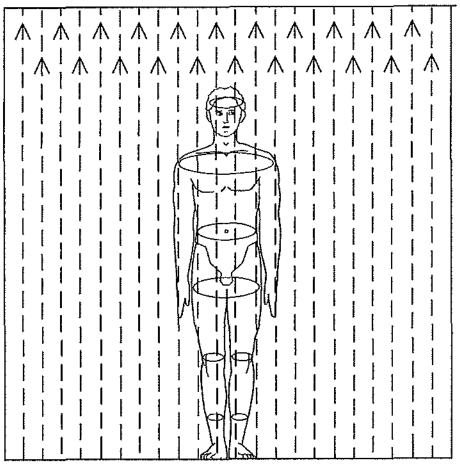
Temperature-regulating measures in the body
Warming: flow of blood through the skin, increase of blood flow rate, vascular enlargement and muscle shivering. Cooling: sweating.

Heat exchange between the body and the surroundings
Inner heat flow: heat flow from the inside of the body to the skin depending on blood circulation. Outer heat flow: heat conduction through the feet; convection (air speed, room air and temperature difference between clothed and unclothed areas of the body); radiation (temperature difference between the external area of the body and the surroundings); evaporation, breathing (body surface, vapour pressure difference between skin and surroundings) → ❶.

Water content of the air (g/kg)	Suitability for breathing	Sensation of breathing
0–5	very good	light, fresh
5–8	good	normal
8–10	satisfactory	still bearable
10–20	increasingly bad	heavy, muggy
20–25	already dangerous	damp heat
over 25	unsuitable	unbearable
41	water content of exhaled air 37°C (100 %)	
over 41	water condenses pulmonary alveoli	

❽ Air humidity values for breathing air

Low radiation temperature. Recommendations for room climatic conditions and temperature of air and surrounding surfaces
In summer, 20–24°C is comfortable, in winter about 21°C (± 1°C). The temperature of the surrounding surfaces should not differ from the air temperature by more than 2–3°C. Alterations of the air temperature can be compensated for to a certain extent by alteration of the temperature of the surrounding surfaces (sinking air temperature – rising surface temperature). If these temperatures are too different, this causes excessive air movement. The critical locations are above all the windows. Large heat transfers to the floor through the feet should be avoided (floor temperature should be greater than 17°C). Hot feet and cold feet are experienced by the sufferers and are not properties of the floor. The bare foot feels heat/cold through the floor covering and its thickness, the clothed foot through the floor covering and the temperature of the floor. The surface temperature of the ceiling depends on the room height. The temperatures perceived by people correspond to approximately the average of the temperature of the air and that of the surrounding surfaces.
Air and air movement. Air movement is experienced as draughts, which in this case result in a local cooling of the body.
Air temperature and relative humidity. Relative humidity of 40–50% is thermally comfortable. If the humidity is less than 30%, dust particles can fly.
Fresh air and air exchange: The ideal is controlled ventilation rather than incidental or permanent ventilation. The CO_2 content of the air must be replaced by oxygen. A CO_2 content of 0.10% by volume should not be exceeded, which requires 2–3 air changes per hour in living rooms and bedrooms. The fresh air required by a person is about 32.0 m^3/h. Air changes in living rooms: 0.4–0.8 × room volume per person/h.

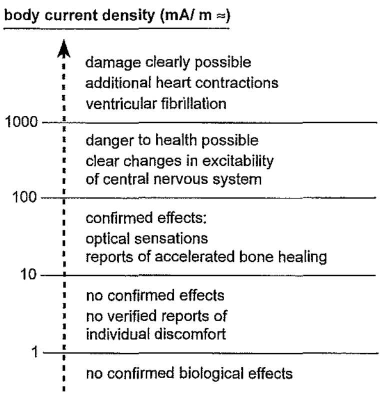


❶ Induction of body currents as the main effect on the body of alternating magnetic and electromagnetic fields

The 26th German Federal Emissions Protection Regulations (BimSchV) lay down **threshold values for electrical field strength and magnetic flux density.** These are, for the mains supply frequency (50 Hz), 5 KV/m or 100 μT, and for railway power supply (16 2/3 Hz) 10 KV/m or 300 μT.

Because of the state of **scientific uncertainty** about the possible effects on health of low-frequency fields, the Federal Office for Radiation Protection (BfS) recommends the following precautionary measures:

Optimise cable runs and isolation of electrical installations to keep the exposure of people as low as possible. Possible field sources and devices should be completely switched off after use and not left in 'standby' mode (this applies particularly to televisions and hi-fi systems). Field sources in sleeping areas (e.g. mains radio-alarm clocks) should be placed as far as possible from beds.



❷ Biological effects of body current densities (BfS → refs)

Device/appliance	3 cm	30 cm	100 cm
telephone	6–2000	0.01–7	0.01–3
electric razor	15–1500	0.08–9	0.01–3
fluorescent lamp	40–400	0.5–2	0.02–0.25
microwave	73–200	4–8	0.25–0.6
television	2.5–50	0.04–2	0.01–0.04
computer	0.5–30	<0.01	
refrigerator	0.5–1.7	0.01–0.25	0.01

❸ Values of magnetic flux densities of household appliances, measured in μT, at various distances (SSK → refs)

The use of technologies like power supply networks and mobile telephones creates various **electrical, magnetic and electromagnetic fields** in the human environment. These can be described through their field strength, given in volt/metre (V/m), their magnetic flux density, in tesla (T), their wavelength, measured in metres (m) and their frequency, in hertz (Hz). This last unit describes the number of cycles per second of the change of polarity of the electrical current. There is a difference between high- and low-frequency fields.

In contrast to ionising radiation (e.g. X-rays), the energy of these fields is not sufficient to electrically charge – to ionise – atoms and molecules. Nonetheless, these fields, above a certain strength, have certain effects on health, and are sometimes described as **'electrosmog'**. The nature and extent of the harmfulness of electrical, magnetic and electromagnetic stimulation for people and environment implied by this term has been the central theme of many building biology investigations.

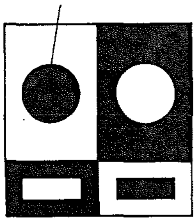
Building biology effects
In everyday life, exposure is mostly from low-frequency electrical and magnetic fields **between 1 Hz and 100 kilohertz (kHz),** which are emitted from the power supply (50 Hz) and electrified transport systems like railways (16 2/3 Hz). In the course of the rapid development of mobile telephones, the population is also increasingly subjected to high-frequency electromagnetic fields of up to **300 gigahertz (gHz).**

If an external **electrical field** acts on a person, then forces act on charges in the body and result in **'body currents'**. This process is called **influence**. In the case of alternating fields, the charge redistribution is constantly repeated at the frequency. Above a certain threshold value, which varies from person to person, electrical fields are perceived. In addition to direct effect, there are also indirect effects of electrical fields, like **discharge currents and electrification.** The causes of this are charge differences between variously charged objects and the affected person. These charge differences reach equilibrium as soon as an electrically conducting contact is created by touching ('shock').

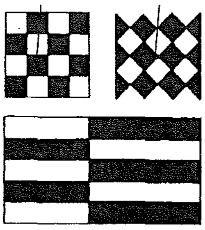
In contrast to an alternating electrical field, an **alternating magnetic field** directly causes currents inside the body as a result of **induction currents.** The decisive parameter for the evaluation of health effects is the density of these body currents, measured in milliampere/square metre (mA/m^2).

Electrical currents also occur inside the body without external fields. Nerves carry their signals by transporting electrical impulses, the heart is electrically active (→ electrocardiogram) and almost all metabolic processes include the movement of charged particles (ions). These natural body currents have densities in the range of 1–10 mA/m^2. **A threshold value of 2 mA/m^2 has been established for the body current density caused by fields.**

Low-frequency electrical and magnetic fields are produced by household appliances and electrical installations. In this case, as with railway traction power and high-voltage cables, the electrical and magnetic field strength reduces rapidly with distance → ❸. Electrical fields present outdoors are mostly shielded by the external walls of buildings, but the shielding of magnetic fields is not possible without great expense. (Drawings and text from: www.bfs.de/elektro, abbreviated – BfS → refs).

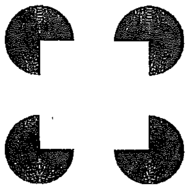


1 Black areas and objects appear smaller than those of the same size that are white; people wearing black clothes seem slimmer, and those wearing white fatter, than they really are. This also applies correspondingly to building elements

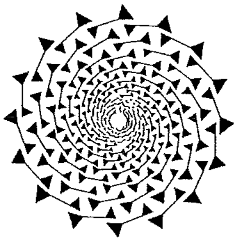


2 If black and white areas are to appear equally large, then the latter have to be correspondingly smaller. A light colour next to a dark colour makes the latter seem darker.

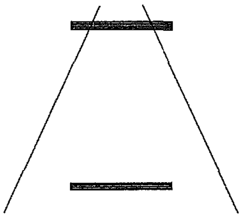
3 Do you see grey circles between the squares? Our brain 'thinks up' these circles.



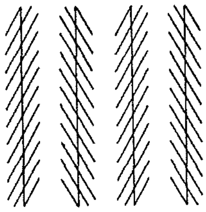
4 Deception of the senses: we think we see a white square. In fact, the outer lines are not there.



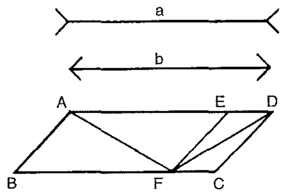
5 Spirals? The picture consists of circles.



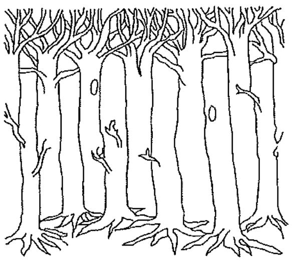
6 The lower line is not shorter than the upper – just an optical illusion.



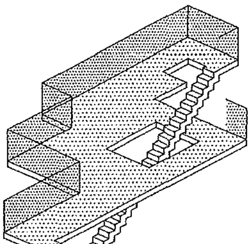
7 The vertical lines are actually parallel in this 'Zöllner figure' but seem to converge due to the hatching.



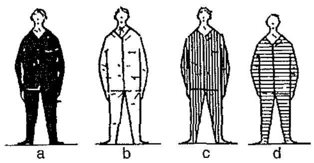
8 The lines a and b appear to be of different lengths due to minor attributes, and A–F and F–D also appear to be different due to inclusion in various figures. They are all the same length.



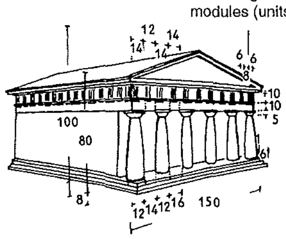
9 How many trees? Not one! There is no connection between roots and crowns.



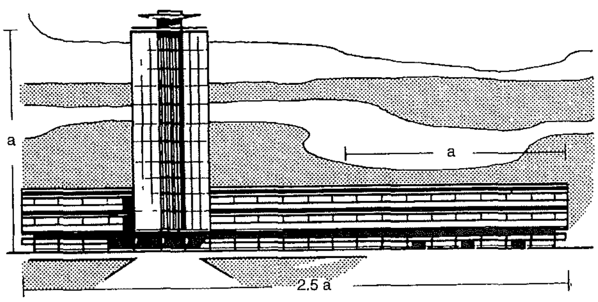
10 Deceptive illustration infringing the conventional rules of perspective.



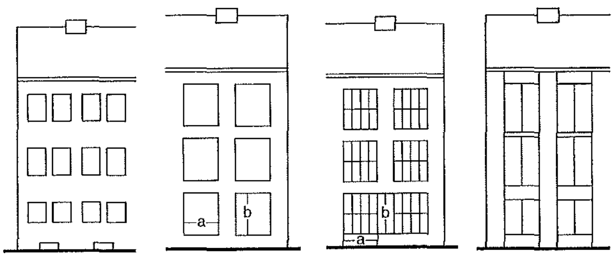
11 The colour and patterning of clothing changes people's appearance.
Black makes people look thin → a, because black absorbs light.
People appear fatter if wearing white → b, because white scatters light.
Vertical stripes increase height → c, horizontal stripes increase width → d.



12 Walls which slant inward with increasing height appear vertical, and steps, cornices and friezes when bowed correctly upwards look horizontal (horizontal curvature)



13 Dimensions in the vertical appear much more impressive than those in the horizontal.



14 Quite apart from the architectural articulation (vertical, horizontal or mixed) → **13**, the perception of scale can be altered just by the ratio of window openings to the remaining area of wall, despite the building and storey heights being the same (window bar layout can have a significant effect).

VISUAL PERCEPTION

The Eye

The activities of the eye can be divided into seeing and observing. Seeing is primarily for our physical safety, but observation starts where seeing stops, leading to the enjoyment of the 'pictures' registered through seeing.

Images perceived by the eye differ according to whether the eye remains still on an object or scans around it. The **still image** is displayed in what approximates to a segment of a circle, whose diameter is the same as the distance of the eye from the object → ❸. Inside this 'field of view', the objects appear to the eye 'at a glance'. The ideal still image appears balanced. Balance is the first characteristic of architectural beauty. (Physiologists are working on a theory of the sixth sense, the balance or static sense, which is also supposed to explain the beauty we see in symmetrical, harmonious objects and proportions → pp. 30–33 or in elements which are in balance.)

Outside this framework, the eye receives its impressions from the **scanned image.** The scanning eye progresses along lines of resistance, which it discovers going away from us in width or depth.

If these lines of resistance are found at even or repeating distances, the eye perceives this as beat or rhythm, which results in a stimulus similar to the ear receiving music ('Architecture, frozen music', Neufert → refs).

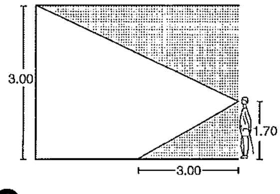
This effect also occurs in a closed room, via the still or scanned image → ❶ – ❷. A room whose upper boundary (the ceiling) is perceived by us in our still image provides a sense of security, but on the other hand in long rooms also a depressed feeling. If the ceiling is higher and the eye only sees it while scanning upwards, then the room is perceived as free, exalted even, always supposing that the wall spacing, and thus the overall proportions, are in harmony.

It should not be forgotten here that the eye is subject to optical illusions. It estimates the width more accurately than depths or heights, which always seem larger. As is well known, a tower seen from above seems much higher than from below → p. 39 ⓭. Vertical edges appear to overhang upwards and horizontal edges appear curved in the middle; see also → p. 39 ❶ – ⓮.

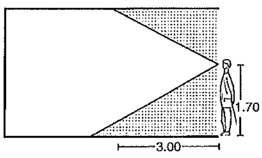
When considering these matters, one should not fall into the opposite way of thinking (exemplified by the Baroque) and, for example, emphasise the perspective effect via inclined windows and cornices (e.g. St Peter's, Rome) or even through cornices, vaulting or similar painted in perspective.

The decisive factors for the measurement of dimensions are the size of the field of view → ❸, or the field of vision → ❹ and, for the exact distinction of details, the size of the field of detailed vision (readability) → ❺ – ❻. The distance of the latter determines the size of the details to be distinguished. The Greeks worked to precisely these principles and determined the size of the smallest bead moulding under the cornice's corona, a different dimension in each temple, so that, at an angular distance of 27°, it always filled the field of detailed vision of 0°1′ → ❼.

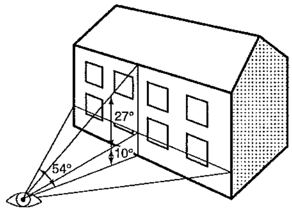
From this also arise the reading distances for books (which vary according to the size of the letters), of audience seats from the performance etc. (Maertens → refs; see here the illustrations developed from his writing → ❸ – ❾).



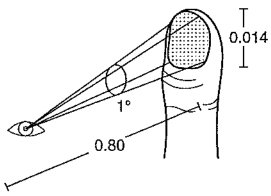
❶ A room with a low ceiling is perceived 'at a glance' (still image)



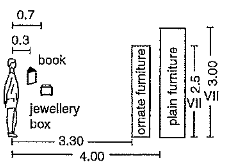
❷ A room with a high ceiling is perceived through the eye scanning upwards (scanned image)



❸ The human field of view, with steady head and moving eye, is 54° horizontally, 27° upwards, 10° downwards.



❹ The field of vision of the fixed normal eye covers 1° of the perimeter, i.e. about the area of the thumbnail of an outstretched hand



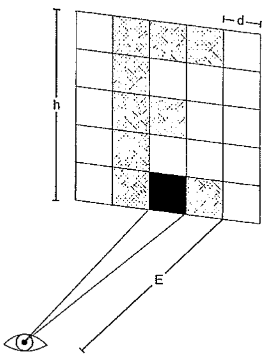
❺ Borderline distances

The eye makes precise distinctions in only 0°1′ of the perimeter = field of detailed vision (readability). The borderline distance **E** of the details to be distinguished can therefore be calculated according to the formula:

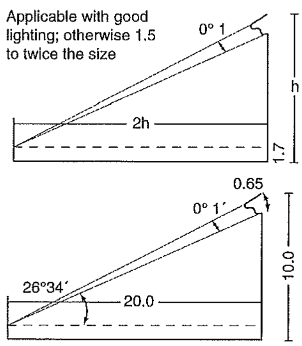
$$E = \frac{\text{size of detail } \mathbf{d}}{\tan 0°1'}$$

Minimum size d of the detail:

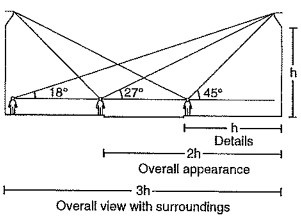
$$\mathbf{d} = \mathbf{E} \times \tan 0°1'$$



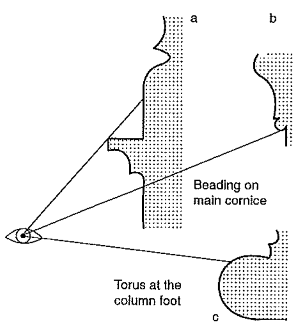
❻ Should, for example, text still be legible at a distance E = 700 m, the width d of the letters must be ≧700 m × tan 0°1′ = 0.204 m (→ ❺); the normal height h for many fonts is 5 × d = 5 × 0.204 = 1.02 m



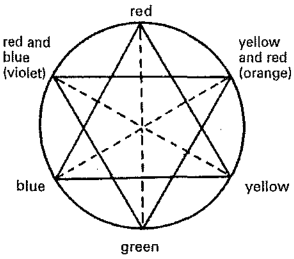
❼ The size of the still distinguishable building elements can be calculated easily using the normal viewing distance and trigonometry (→ ❺)



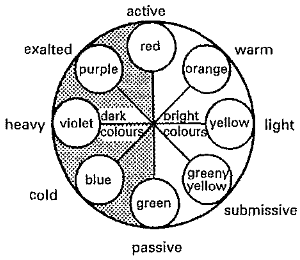
❽ The above distances are appropriate for street widths, if the intention is to permit an overview and the observation of details.



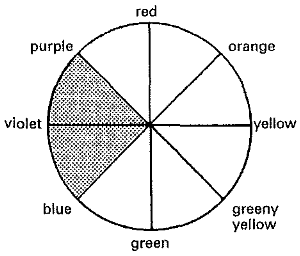
❾ Building elements intended to be seen but located above projections must be high enough (a); single elements can present larger surfaces to the eye through slight deformations (b, c)



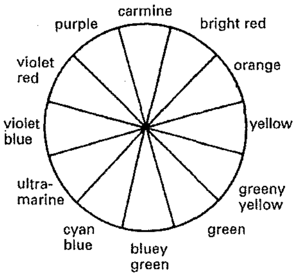
❶ Goethe's colour circle: basic colours – red-blue-yellow; mixed colours: green-orange-violet (= mixed colours of the first rank, obtained by mixing the basic colours)



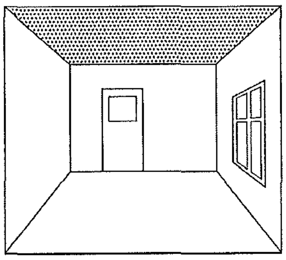
❷ Dark and bright colours and their effect on people



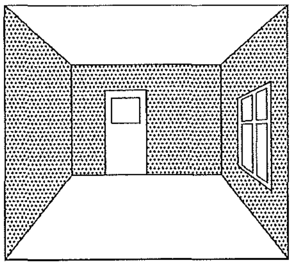
❸ Heavy and light colours (not the same as dark and light colours) → ❷.
(In addition to the darkness, the natural red component is also decisive for the impression of heaviness)



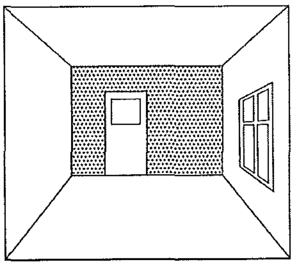
❹ The 12-segment colour circle



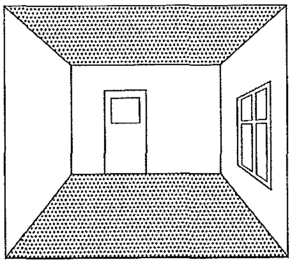
❺ Rooms seem lower when the ceiling is heavily coloured



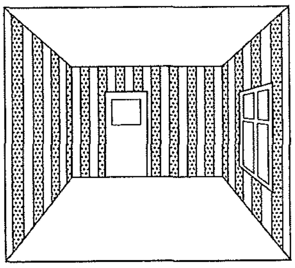
❻ Colourful side walls seem to extend the room upwards and downwards



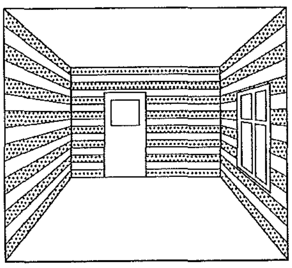
❼ Colourful end walls make long rooms seem shorter



❽ Colourful floors and ceilings make rooms seem lower and wider



❾ Vertical stripes make walls seem higher



❿ Horizontal stripes widen the wall and the room seems lower

Colours have a power over people. They can create feelings of well-being, unease, activity or passivity. Paint schemes in factories, offices or schools can improve or dull performance, in hospitals can improve the health of the patients. The influence of colour on people can take place indirectly through physiological effect, for example making rooms appear wider or narrower, leading to an oppressive or liberating feeling → ❺ – ❿. Colour's influence is also exercised directly through impulses produced by each colour → ❷ – ❸. Orange has the strongest impulse power, followed by yellow, red, green and purple. Blue, turquoise and violet (cold and passive colours) have the lowest power.

Strongly impulsive colours are suitable only for small areas within rooms, but non-impulsive colours can be used across extensive stretches. Warm colours have an active effect, stimulating or even exciting. Cold colours are passive, calming or spiritual. Green is relaxing for the nerves.

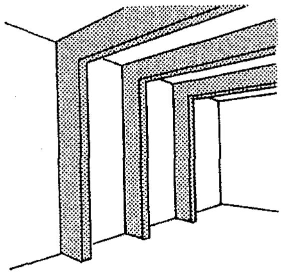
The effect produced by colours also depends on their brightness and location. Warm and light shades viewed overhead have a mentally stimulating effect; at the side, warming and coming close; below, relaxing and lifting. Warm and dark colours overhead exert an enclosing and dignified influence; at the side, surrounding; below, they offer secure grip and footing.

Cold and light colours viewed overhead are brightening and, relaxing; at the side, they seem to lead away; below, they are smooth and encourage walking. Cold and dark colours viewed overhead are threatening; at the side, cold and sad; below, burdensome and dragging down.

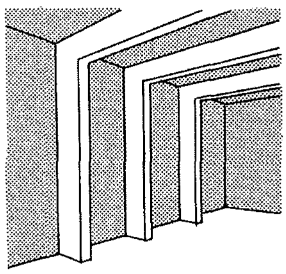
White is the colour of absolute purity, cleanliness and order. White plays a major role in interior design, to separate and neutralise other colour groups, then to structure them with light and vitality. As the colour of order, white is used to denote areas in warehouses and car parks, and for road markings.

white paper	84	pure turquoise blue	15
lime white	80	grass green	≈ 20
lemon yellow	70	pastel green	≈ 50
ivory	≈ 70	silver grey	≈ 35
cream	≈ 70	lime plaster grey	≈ 42
pure gold yellow	60	dry concrete grey	≈ 32
straw yellow	60	plywood	≈ 38
light ochre	≈ 60	yellow brick	≈ 32
pure chrome yellow	50	red brick	≈ 18
pure orange	25–30	dark brick	≈ 10
light brown	≈ 25	Solnhofen slab	≈ 50
pure beige	≈ 25	medium stone	35
medium brown	≈ 15	dry asphalt	≈ 20
salmon pink	≈ 40	wet asphalt	≈ 5
full scarlet red	16	dark oak	≈ 18
vermilion red	20	light oak	≈ 33
carmine red	10	walnut	≈ 18
deep violet	≈ 5	light spruce	≈ 50
light blue	40–50	aluminium foil	83
deep sky blue	30	zinc plated steel	16

⓫ Brightness of surfaces. Values between theoretical white (100%) and absolute black (0%)



⓬ Dark single elements in front of light walls are powerfully emphasised



⓭ Light elements in front of dark walls seem even lighter