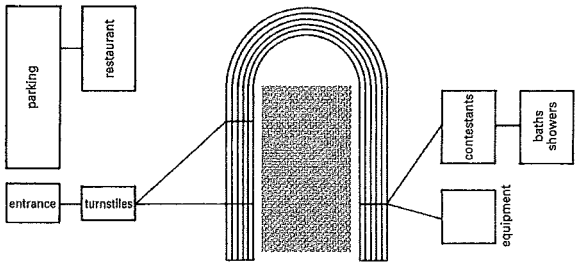
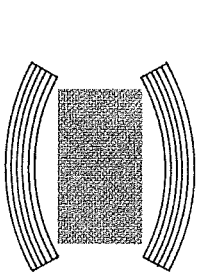
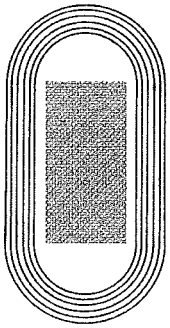


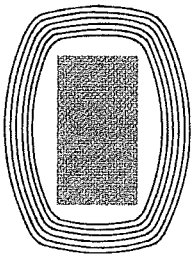
❶ U-shaped layout



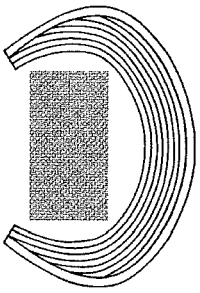
❷ USA = segmented layout



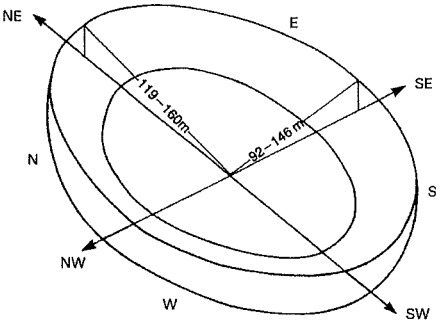
❸ Amsterdam = semi-circular ends



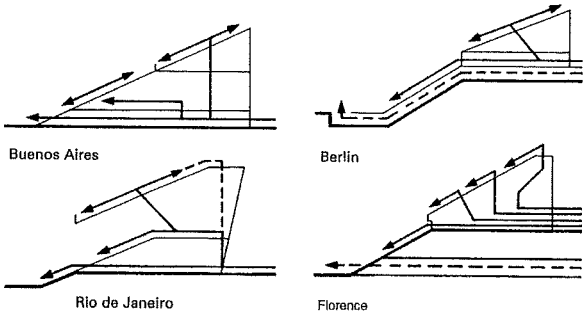
❹ Rotterdam = curved sides and corners. Only for football



❺ Budapest = horseshoe around transverse axis



❻ Viewing distance determines size of sports ground



❼ Spectator traffic routes at various stadiums

STADIUMS

Overview

Ancient stadiums, whose size has never been matched (the Circus Maximus in Rome had room for 180,000 spectators), still form the basis for today's sports venues. The dimensions are normally determined by the 70 × 109 m layout of a football pitch and the running track around it → p. 323. The basic shape of the playing area is an ellipse, which is similar to the ancient egg shape. A stadium is normally partially dug into the ground and the earth removed is heaped around it. From the town planning aspect, sports facilities must fit well into the terrain and the transport and utility supply conditions should be good: rail, bus, tram stops, large car parks etc. Industry in the immediate vicinity should be avoided because smoke, smell and noise are undesirable. Covered and open-air facilities for various types of sport can be combined and integrated into the zoning plan of the city.

The orientations of ancient arenas were usually west–east or south–north, according to the various times of competitions → ❻; in Europe, northeast–southwest so that most spectators had the sun behind them. Open entrances are therefore at the eastern end. The pay booths were placed far forward, and behind them the flow of visitors distributed itself to various points in the stadium. These provide access, mostly up the heaped areas, or up stairs, to the stand at half-height and then to the rows above and below → ❼. For acoustic reasons, the Roman architect Vitruvius recommended a fixed gradient of 1:2 for both rows of seating and standing places. Nowadays, when loudspeakers are used, the inclination only has to ensure a good view.

Accordingly, with staggered seats, the audience in each row should be able to see over the heads of those two rows in front. This results in a parabolic curve. The best viewing conditions are from the long side of an arc.

The width of the access passages and stairs must be worked out using the sudden flow of spectators leaving (in contrast to the gradual trickle of those arriving). According to the calculations of C. van Eestern, each 5000 spectators at the Amsterdam stadium → ❸ require 7 minutes (or 420 seconds) to leave using the 9.5 m wide stairs provided (in Los Angeles 12 minutes, in Turin 9 minutes).

So one spectator uses 1 m stair width in

$$\frac{9.5 \times 420}{5000} = 0.8 \text{ s}$$

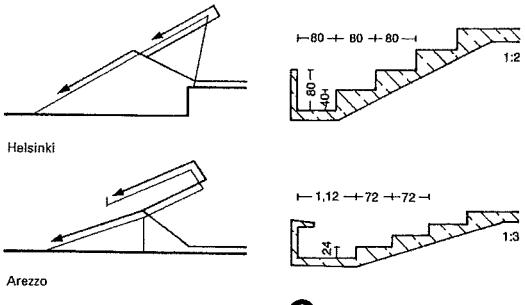
or in 1 s, for each 1 m stair width,

$$\frac{5000}{9.5 \times 420} = 1.25 \text{ s}$$

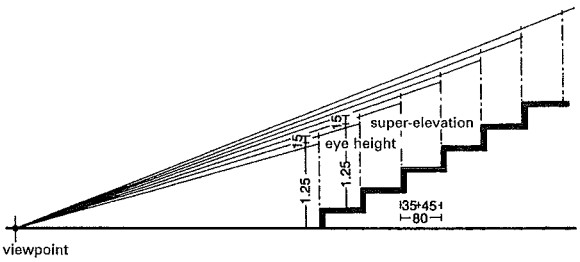
spectators leave. The formula for the necessary stair width for a defined number of spectators intending to leave the stadium in a desirably short time would therefore be

$$\text{stair width (m)} = \frac{\text{no. spectators}}{\text{evacuation time (s)} \times 1.25}$$

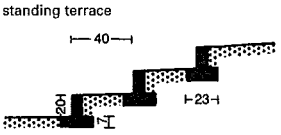
First-aid rooms should be provided according to the number of spectators and close to the spectator area. A group of rooms is necessary for every 20,000 spectators: treatment and rest room 15 m², store room 2 m² and two toilets with lobbies to prevent odour transmission. For stadiums with room for more than 30,000 spectators, there should also be a 15 m² room for public safety personnel (police, fire service). The commentary boxes will be in the main stand with a good view of the sports field, each box 1.5 m². Behind every five media boxes, a switchroom of 4 m². One car parking space for every four spectators and parking places for coaches should be allocated.



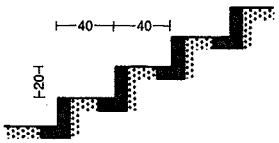
❽ Stand sections



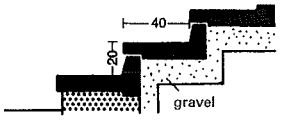
1 Sight line construction



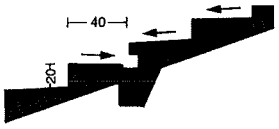
2 Concrete units



3 → 2

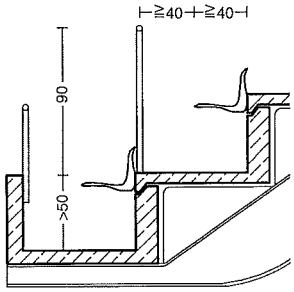


4 → 2

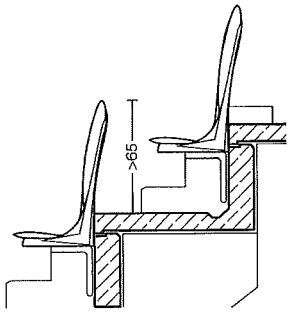


5 Sloping reinforced concrete with drainage

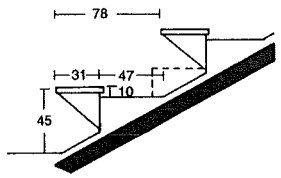
seating steps



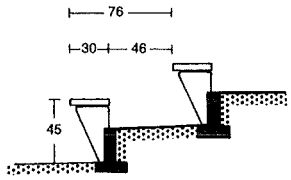
6 Steps > 50 cm high must be provided with fall protection min. 90 cm high



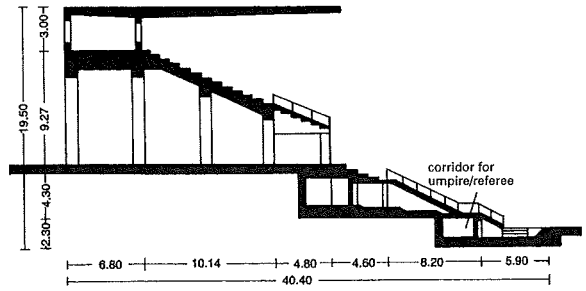
7 If backrests are > 65 cm high, barriers can be omitted



8 Sloping reinforced concrete slab with steps



9 No fall protection is required for steps < 50 cm high



10 Section through the Berlin Olympic stadium Arch.: Prof. Werner March

Spectator and VIP areas

The design is based on the relevant state Places of Assembly Regulations, which contain requirements for access routes, stairs, ramps and spectator places. Further regulations can be prescribed by ruling sports bodies, e.g. the FIFA guidelines for international games prohibit standing places in stadiums.

According to the number of spectator places planned, stands are either placed on the long sides of the sports field (a good view, because the distance is not too far) or, for more than approx. 10,000 places, around the entire playing area. Because sporting events mostly take place in the afternoon, the best spectator places are on the west side (no glare).

If the spectator places are arranged in a multi-row layout, sufficient super-elevation should be provided to improve the viewing conditions. For smaller stands with up to 20 rows of standing places or 10 rows of seating, this can be a linear gradient of 1:2, but in all other stadiums the linear gradient should be parabolic. In this case the gradient for sitting and standing places can be determined by using spectators' sight line construction, with the super-elevation 12 cm for standing places and 15 cm for rows of seats → 1.

Seated areas (Places of Assembly Regulations)

Seated place width 0.5 m

For design purposes, in rows of seating the required space is two visitors per m². This can be provided as row seating (benches) or as individual seats, which have to be fixed and immovable when there are more than 5000 visitor places. Seats with backrests offer more comfort (height min. 30 cm according to FIFA guidelines) and there must be a clear passage width of 40 cm between rows of seats. Seats must be arranged in blocks of max. 30 rows. Behind and between the blocks, there must be aisles with a min. width of 1.20 m. Depending on the layout of the access and exit routes, each row of seats may contain:

20 places if there is an aisle to the open air at one side, or

40 places if there is an aisle to the open air at both sides

Sitting and standing places must be separated. A 1.20 m width of escape route (stairs, ramps, level surfaces) must be provided for every 600 places, with a minimum width of 1.20 m.

Standing terraces (Places of Assembly Regulations)

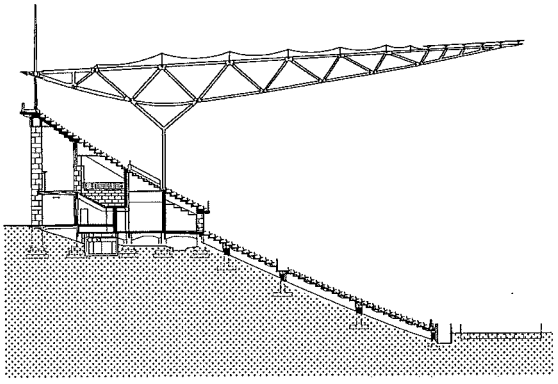
Standing space width 0.5 m

For design purposes, in standing terraces the required space is two visitors per running metre of terrace. A 1.20 m width of escape route (stairs, ramps, level surfaces) must be provided for every 600 places, with a minimum width of 1.20 m. In order to ensure that standing areas fill and empty evenly and to avoid dangerous crushes, they should be divided into blocks of about 2500 places. These blocks should be fenced apart and separately accessed.

Within a block of standing terrace, 'wave breakers' (crush barriers) should be provided. It must be ensured that, seen from each standing place, there is a suitably strong parapet about 1.1 m high within 10 rows. Possible diagonal surging must be hindered by a staggered arrangement of the 'wave breakers'.

VIPs: Larger stadiums should provide a covered VIP box with movable seating.

Roofing of stands: The intention should be to provide cover for as many places as possible. Overlapping of stand structures can increase the number of covered places. The Berlin Olympic stadium has recently received a new roof → 10 – 11.

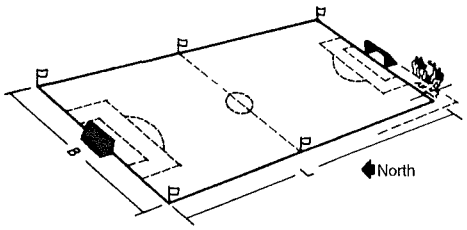


11 Section through the Berlin Olympic stadium after rebuilding Arch.: Gerkan Marg u. Partner

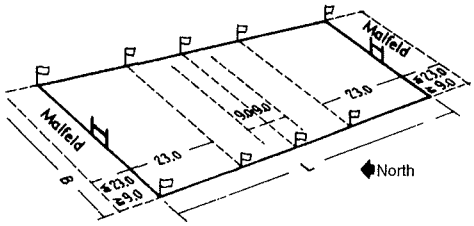
SPORTS FACILITIES

Playing Areas

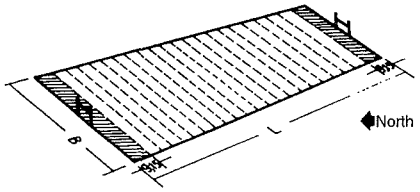
Sport	Competitive sport				Leisure sport				Net	Goal / basket (m)
	Playing area dimensions (m)	Free space around sides (m)	Free space around ends (m)	Total area (m)	Playing area dimensions (m)	Free space around sides (m)	Free space around ends (m)	Total area (m)	Height (m)	W = width H = height
Football	45–90 × 90–120	1	2	46–91 × 92–122	68 × 105	1	2	69 × 107	—	W = 7.32 H = 2.44
Football, FIFA requirements	45–90 × 90–120	2	3.5	47–92 × 93.5–123.5	68 × 105	2	3.5	70 × 108.5	—	W = 7.32 H = 2.44
Rugby	68.4 × 100	2	12–23	70.4 × 123	68.4 × 100	2	12–23	70.4 × 123	—	W = 5.60 H = 3.00
Handball	55–65 × 90–110	1	2	56–66 × 92–112	60 × 90	1	2	61 × 92	—	W = 3.00 H = 2.00
Indoor handball	18–22 × 38–44	1	2	19–23 × 40–46	20 × 40	1	2	21 × 42	—	W = 3.00 H = 2.00
Hockey (field hockey)	—	—	—	—	55 × 91.4	2	4	57 × 95.4	—	W = 3.66 H = 2.14
Netball	25 × 60	1	2	26 × 62	25 × 60	1	2	26 × 62	—	net H = 2.50
Softball/ rounders	25 × 50–70	10	10	35 × 60–80	—	—	—	—	—	pole H = 1.50
Indoor cycle polo	9–11 × 12–14	0.5	0.5–1	9.5–11.5 × 13–15	—	—	—	—	—	W = 2.00 H = 2.00
Volleyball	9 × 18	2	3	11 × 21	9 × 18	2	3	11 × 21	2.43	—
Prellball	8 × 16	2	4	10 × 20	8 × 16	2	4	10 × 20	—	—
Schleuderball	—	—	—	—	15 × 100	8	30	23 × 130	—	—
Fistball	—	—	—	—	20 × 50	6	8	26 × 58	2.00	—
Basketball	15 × 28	1	1	—	—	—	—	—	—	3.05
Streetball	13–15 × 24–28	1 2	1 2	14–16 × 26–30	—	—	—	—	—	3.05



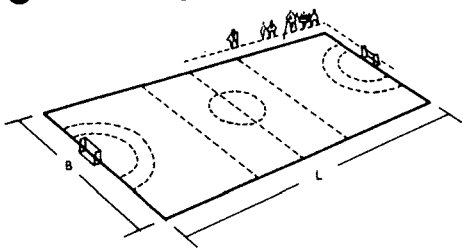
1 Football



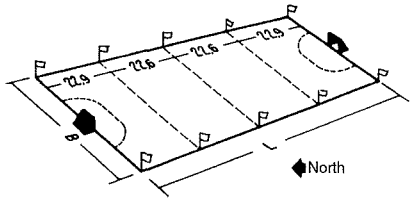
2 Rugby (German)



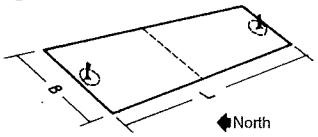
3 American football, goals 5.50 × 3.05 m



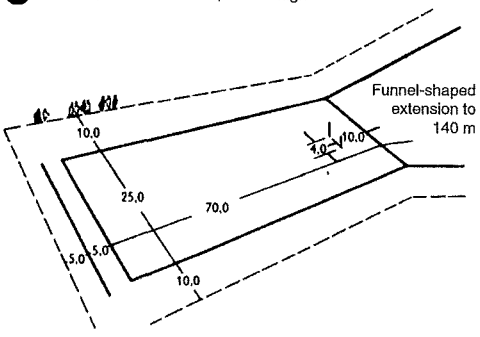
4 Handball



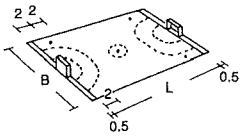
5 Hockey



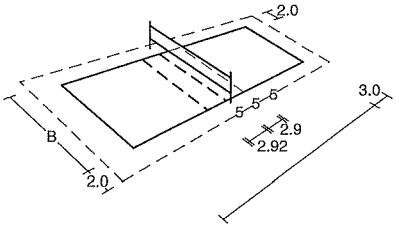
6 Netball, net diam. 55 cm, 2.50 m high



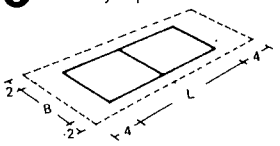
7 Softball/rounders



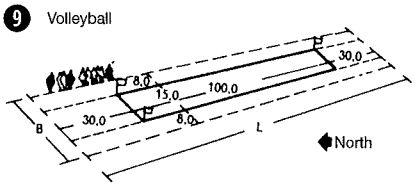
8 Indoor cycle polo



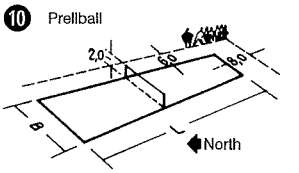
9 Volleyball



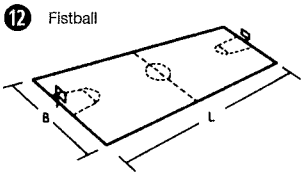
10 Prellball



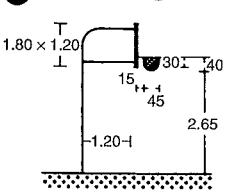
11 Schleuderball



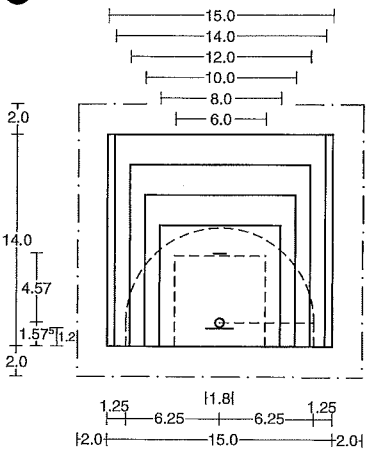
12 Fistball



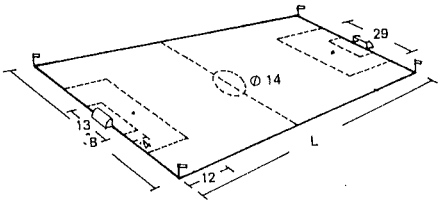
13 Basketball → 14



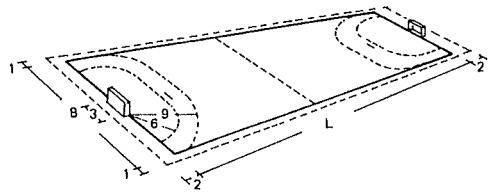
14 Basketball basket → 13 + 15



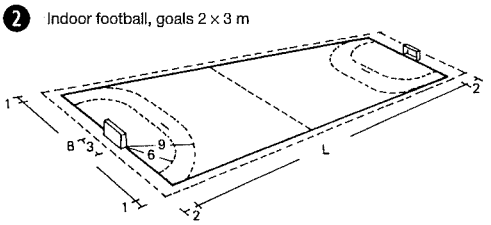
15 Streetball → basket 14



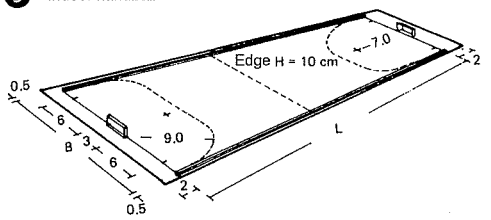
1 Small playing field for school football



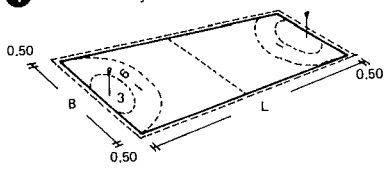
2 Indoor football, goals 2 × 3 m



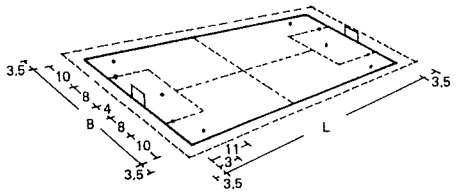
3 Indoor handball



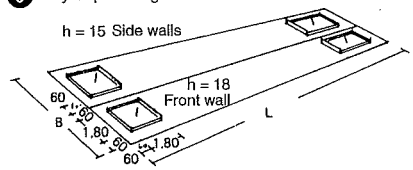
4 Indoor hockey



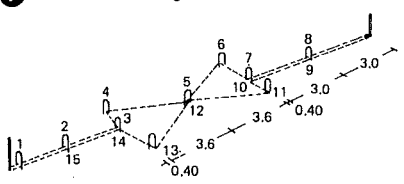
5 Indoor netball, net diam. 0.55, 2.5 m high



6 Cycle polo on grass



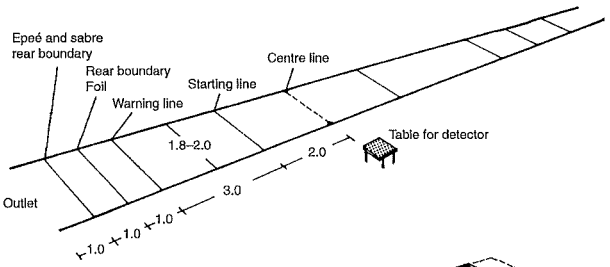
7 Horseshoe throwing



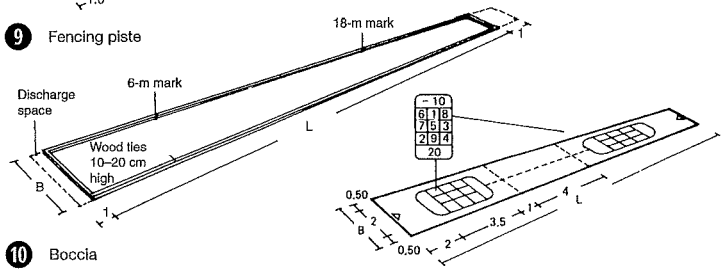
8 Croquet lawns

Playing area size (m)						
Game	max.		min.		Standard dimensions[1]	
	L	W	L	W	L	W
1 School football	70	40	40	20	44	22
2 Indoor football	50	25	40	20	44	22
3 Indoor handball	—	—	—	—	44	22
4 Indoor hockey	40	20	36	18	44	22
5 Indoor netball	60	25	64	27	—	—
6 Cycle polo on grass	—	—	—	—	60	40
7 Horseshoe throwing	15	3	12	3	—	—
8 Croquet	—	—	—	—	20	4
9 Fencing piste	24	2	13	1.80	—	—
10 Boccia	—	—	—	—	24	3
11 Shuffleboard	—	—	—	—	17	3
12 Tennikoit	12.20	5.50	—	—	18.20	11.50
13 Baseball	—	—	—	—	18.29	18.29

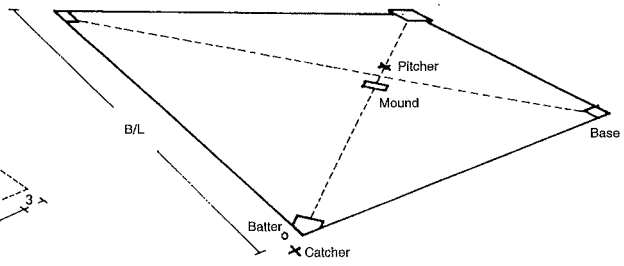
[1] including safety margin



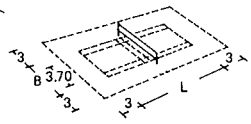
9 Fencing piste



10 Boccia

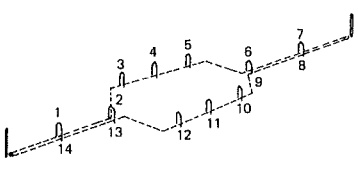


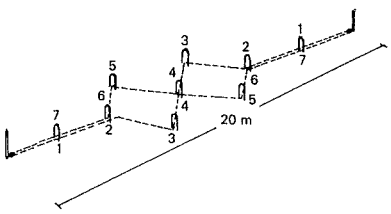
11 Shuffleboard

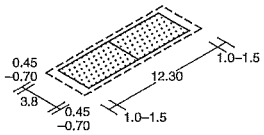


12 Tennikoit

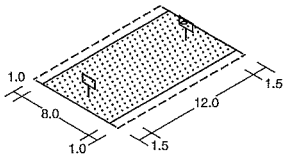
13 Baseball



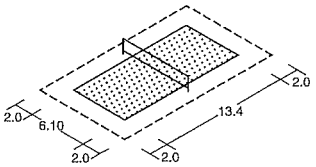




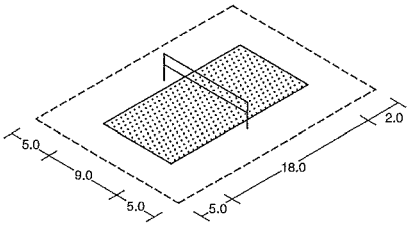
1 Beachminton



2 Beach basketball



3 Beach badminton (competitive)

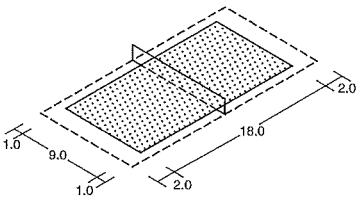


4 Beach volleyball (competitive)

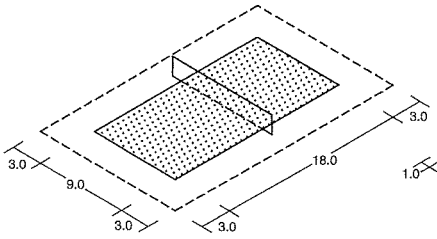
Beach sport type	Competitive sport				Leisure sport				Net	Goal/basket	Sports hall
	Size of playing area (m)	Free space around sides (m)	Free space around ends (m)	Total area (m)	Size of playing area (m)	Free space around sides (m)	Free space around ends (m)	Total area (m)	Height (m)	W = width H = height (C) = competition (m)	Clear height (m)
Volleyball	18.00 × 9.00	5.00	5.00	28.00 × 19.00	18.00 × 9.00	3.00	3.50	25.00 × 1500	2.24 F 2.43 M	—	reg >5.50 nat >7.00 int >12.50
Football ('professional')	36.00 × 28.00	1.00	2.00	40.00 × 30.00	—	—	—	—	—	W=7.32 (C) H=2.44 (C)	—
('amateur')	31.00 × 25.00	1.00	2.00	35.00 × 27.00	—	—	—	—	—	W=5.00 (C) H=2.00 (C)	—
	—	—	—	—	27.00 × 12.00	1.50	1.50	30.00 × 15.00		W=3.00 H=2.00	—
Football tennis	—	—	—	—	18.00× 9.00	1.00	2.00	22.00 × 11.00	1.30	—	—
Sepak takraw	18.00 × 9.00	2.00	2.00	22.00 × 13.00	12.00 × 6.00	2.00	2.00	16.00 × 10.00	1.10	—	—
Handball	27.00 × 12.00	3.00	3.00	33.00 × 18.00	27.00 × 12.00	1.50	1.50	30.00 × 15.00	—	W=3.00 H=2.00	—
Badminton	13.40 × 6.10	2.00	2.00	17.40 × 10.10	13.40 × 6.10	1.50 exceptionally. 0.30	2.00 exceptionally 1.30	16.40 × 10.10	1.55	—	reg >7.00 nat >7.00 int >9.00
Beachminton	12.30 × 3.80	0.45 0.70	1.00 1.50	14.30 × 4.70 15.30 × 5.20	12.80 × 3.80	0.30	0.35	13.00 4.40	1.28	—	reg >5.20 nat >6.50 Int >9.00
Basketball	12.00 (basket spacing)	—	—	—	15.00 × 8.00	1.00	—	15.00 × 10.00	—	12.00 (basket spacing)	—
Tennis (single court)	18.00 × 9.00 18.00 × 6.00	3.00 3.00	3.00 3.00	24.00 × 15.00 24.00 × 12.00	18.00 × 9.00 18.00 × 6.00	300 300	3.00 3.00	24.00 × 15.00 24.00 × 12.00	1.50 1.50	—	reg >7.00[1] nat >9.00 int >9.00
TAMbeach (single court)	24.00 × 11.00 24.00 × 7.50	1.00 1.00	2.00 2.00	28.00 × 13.00 28.00 × 9.50	18.00 × 9.00 18.00 × 6.00	1.00 1.00	2.00 2.00	22.00 × 11.00 22.00 × 8.00	2.10 to 2.15	—	—

[1] Regional leisure sport can take place from a hall height of 5.50 m

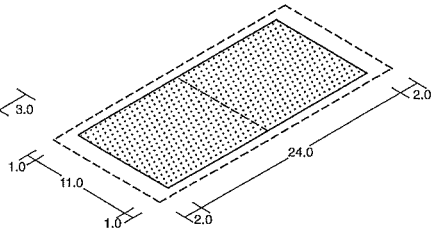
7 Dimensions of beach playing areas



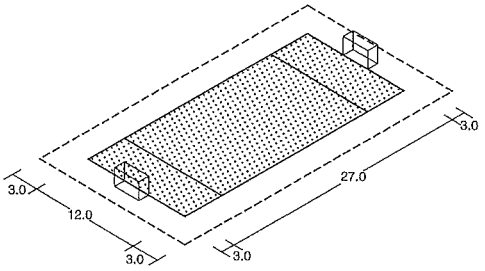
5 Beach football tennis



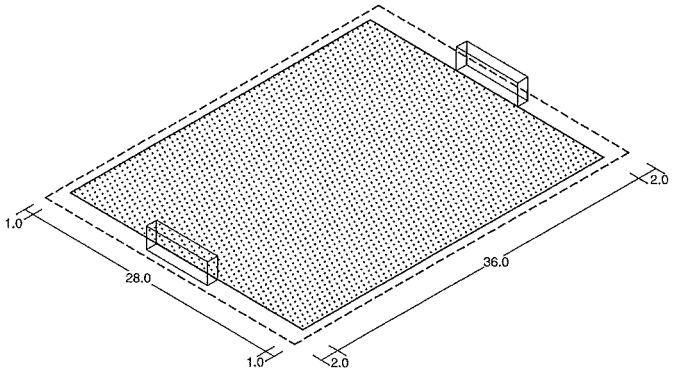
8 Beach tennis (doubles)



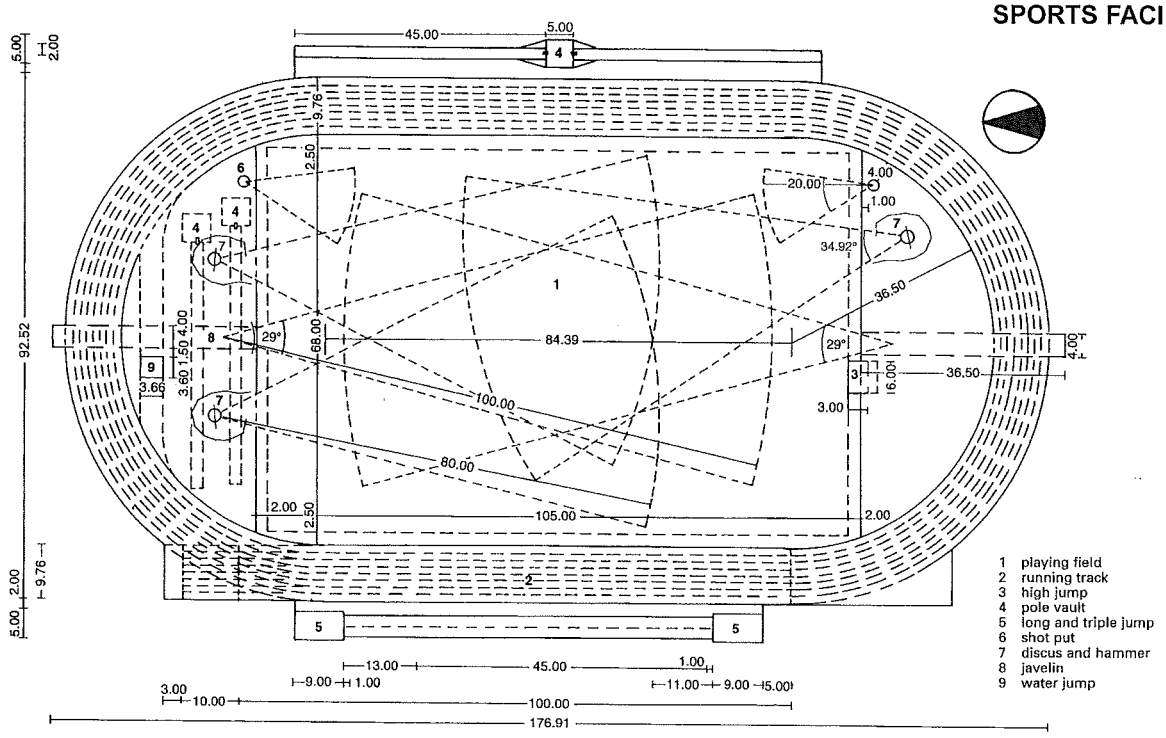
9 TAMbeach (competitive)



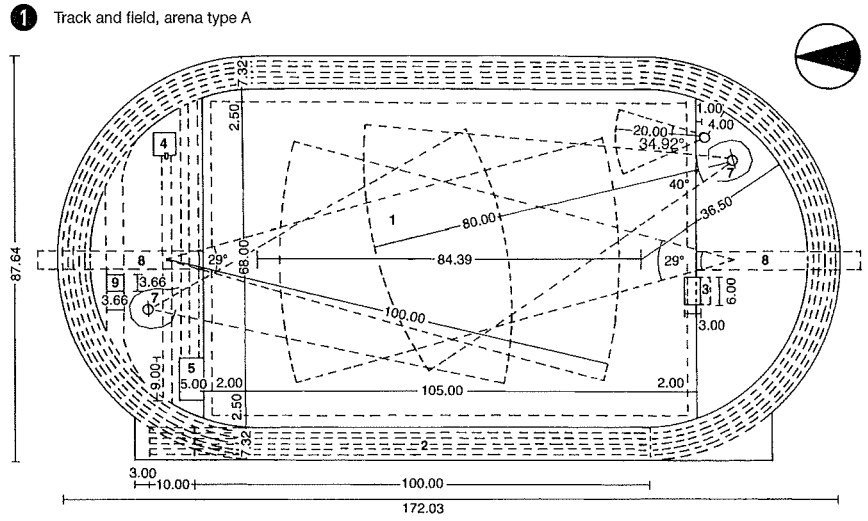
6 Beach handball (competitive)



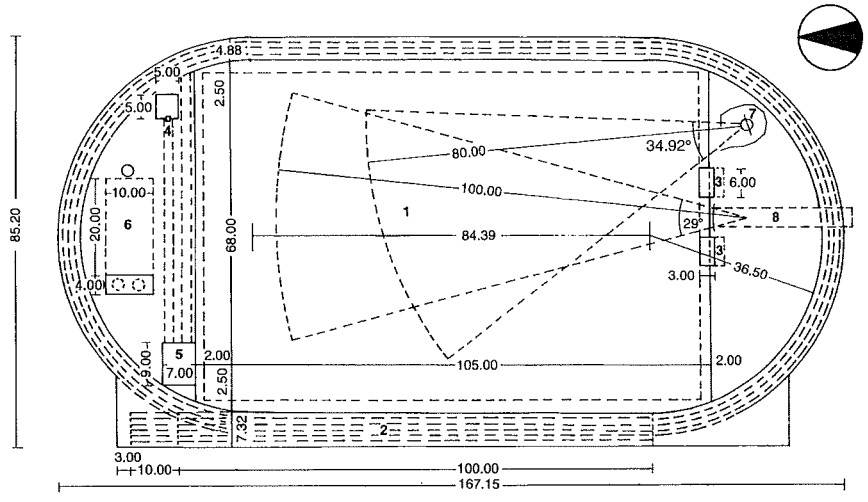
7 Beach soccer



1 Track and field, arena type A



2 Track and field, arena type B

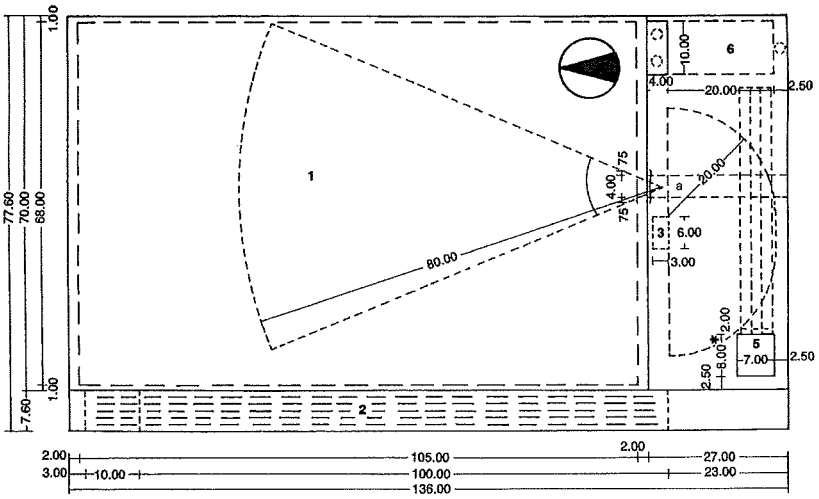


3 Track and field, arena type C

Track and field, arena type A
This consists of an eight-lane perimeter track and large inner field; shot put, discus/hammer throwing, high jump and javelin in southern segment; shot put, discus/hammer throwing, javelin and water jump for obstacle race in northern segment; pole vault pit with run-up from both sides on eastern side outside perimeter track; long jump and triple jump pit with two run-ups on western side outside perimeter track.

Track and field, arena type B
This consists of a six-lane perimeter track and large inner field; shot put, discus/hammer throwing, high jump and javelin in southern segment; pole vault, javelin, discus/hammer throwing, long jump with three run-ups and water jump for obstacle race in northern segment; pole vault, long jump and triple jump pits can also be arranged outside perimeter track.

Track and field, arena type C
This consists of four-lane perimeter track and large inner field; discus/hammer throwing, high jump and javelin in southern segment; pole vault, discus/hammer throwing, long jump and triple jump pits with three run-ups and shot putting in northern segment.



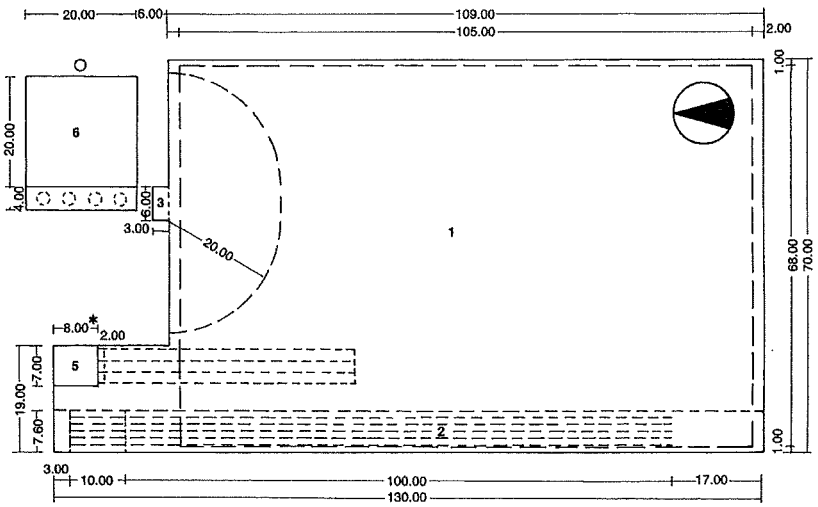
1 Track and field, arena type D

* 9.00 m for competitions (take-off board offset 1.00 m)
8.00 m for training (take-off board offset 2.00 m – see also the following page)

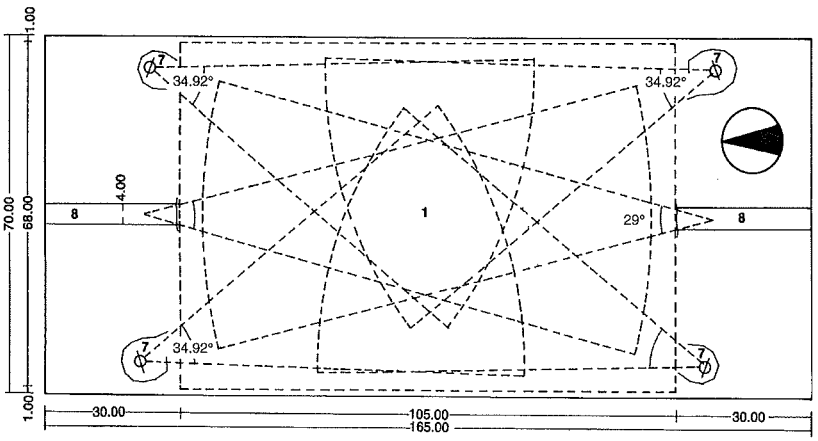
1 playing field
2 running track
3 high jump
4 pole vault
5 long jump
6 shot put
7 discus and hammer
8 javelin and ball throwing

Track and field, arena type D consists of facilities for the following events → 1:
4–6 single lanes for straight sprints and straight hurdles
1 playing field 68 × 105 m (70 × 109 m including safety zones)
1 shot put practice area, throwing southwards
1 triple facility for long jump, triple jump; run-up to the west
1 high jump area; run-up northwards
1 shot put ring; throwing direction northwards
1 softball throwing area; throwing direction northwards
1 small playing field 27 × 45 m (including safety zones)
The running track in type D is normally clay paved, but synthetic paving is recommended for very heavy use.

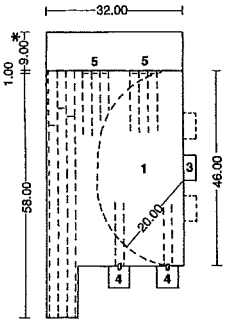
A **combined large field** includes a large playing field, with areas for track and field events next to and on the field. It consists of the following areas: → 2
1 playing field 68 × 105 m (70 × 109 m with safety zones)
1 high jump area; run-up northwards over the field
1 shot put practice area; throwing direction eastwards
1 shot put ring; throwing direction westwards
For practice in throwing disciplines, the provision of a run-up or throwing field is recommended for safety reasons. This consists of a grass area for landing about the size of a large field and a run-up or throwing area for javelin, discus and hammer on the southern short side → 3.



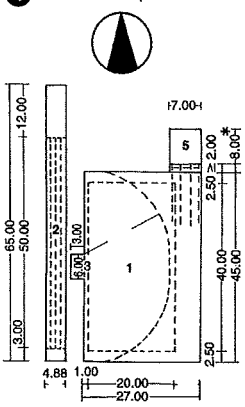
2 Combined large field



3 Throwing field



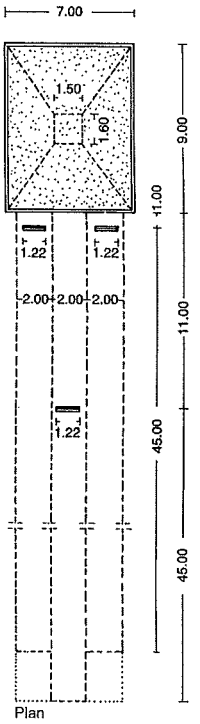
4 Central run-up field



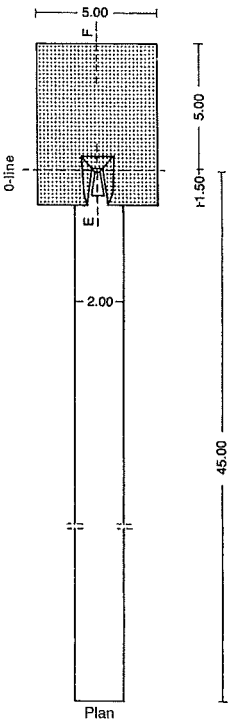
5 Combined small field

Sport and leisure

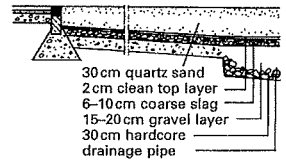
SPORTS FACILITIES
Playing areas
Athletics
Tennis
Miniature golf
Golf courses
Water sport, marinas
Water sport, rowing and canoeing
Equestrian sport
Ski jumping
Ice rinks
Roller skating rinks
Speed roller skating, skateboarding
Cyclo-cross, BMX
Shooting ranges



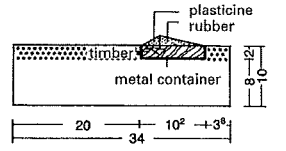
1 Long jump and triple jump layout



2 Pole vault layout → 5

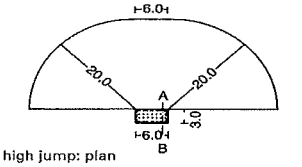


section through long jump pit

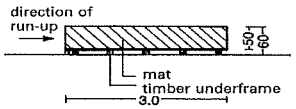


section through take-off board

3 Long jump and triple jump details

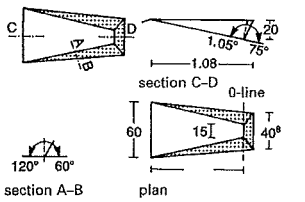


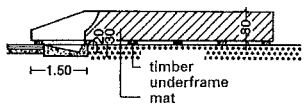
high jump: plan



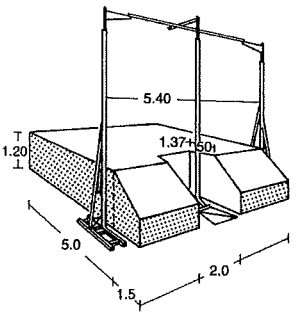
section A–B through mat and mat-frame

4 High jump layout and details





5 Pole vault details → 2
section E–F

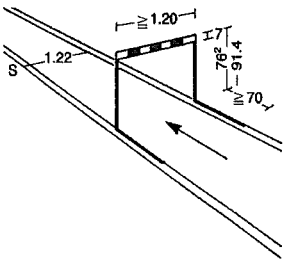


6 Sprung stand and landing pad for pole vault → 2

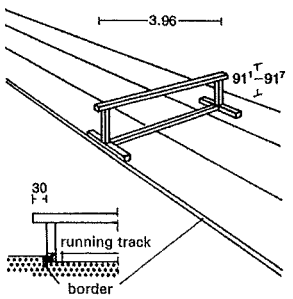
Area for:	Run-up length (m)	Width (m)	Pit (P) or landing pad (L)	Length (m)	Width (m)
long jump	≧45[1]	1.22[2]	P	≧8	2.75
triple jump	≧45[3]	1.22[2]	P	≧8	2.75
pole vault	≧45	1.22	LP	≧5	5.00
high jump	semicircle r ≧2.00		L	3	5–6

[1] the take-off board is min. 1 m in front of the pit, because the distance between the take-off line and the end of the landing area must be at least 10 m. For high-standard layouts, the landing area is 9 m long.
[2] for multiple layouts, the width of each lane is 2 m.
[3] the take-off board is 11 m in front of the landing area (for juniors 9 m, for top athletes 13 m).

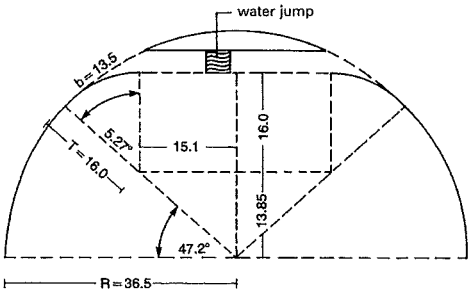
7 Dimensions for jumping sports → 1 – 2



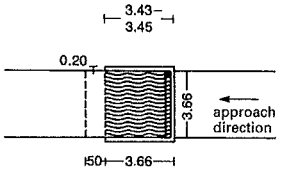
8 Hurdle with counterweight



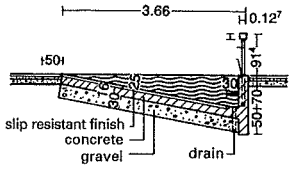
9 Hurdle



10 Obstacle race with 16 m radius and water trough



11 Water jump



12 Steeplechase water jump

Type of track	Length of start (m)	Track	Run-out	Width of each lane[1]
sprint	3	110[2]	17	1.22
circular	—[3]	400	17	1.22

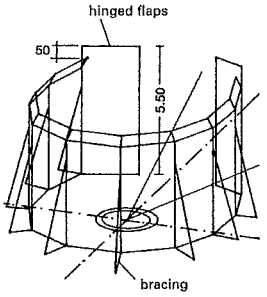
[1] the circular track needs an additional 28 cm safety zone, which does not have to be constructed as a track
[2] the length of 110 m results from the 110 m hurdles; for other sprint events the distance is 100 m
[3] no additional starting space necessary

13 Track dimensions → 8

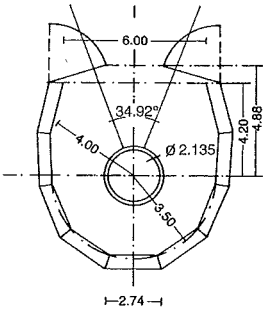
Track length (m)	Class	No. hurdles	Height of hurdles (m)	Distance to first hurdle (m)	Spacing of hurdles (m)	Distance after last (m)
400	Men and men, junior A + B	10	0.914	45.00	35.00	40.00
400	Women and women, junior A	10	0.762	45.00	35.00	40.00
110	Men	10	1.067	13.72	9.14	14.02
110	Men, junior A	10	0.996	13.72	8.90	16.18
110	Men, junior B	10	0.914	13.50	8.60	19.10
100	Women and women, junior A	10	0.840	13.00	8.50	10.50
100	Women, junior B (from 1984)	10	0.762	13.00	8.50	10.50
100	Women, junior B (from 1983)	10	0.840	12.00	8.00	16.00
80	Schoolboys A	8	0.840	12.00	8.00	12.00
80	Schoolgirls A	8	0.762	12.00	8.00	12.00
60	Schoolboys and schoolgirls B	6	0.762	11.50	7.50	11.00

Note: a tolerance of ± 3 mm is allowed in the standard height

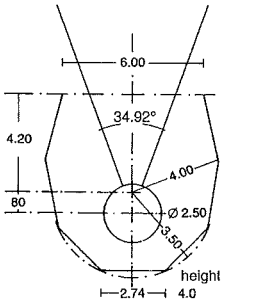
14 Hurdle tracks → 8



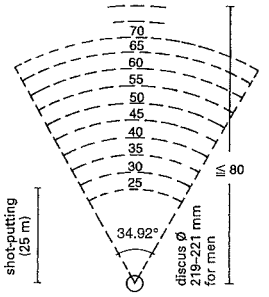
❶ Side view of combined hammer throwing circle and cage → ❷



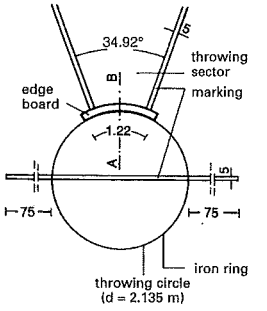
❷ Plan of hammer throwing circle and cage



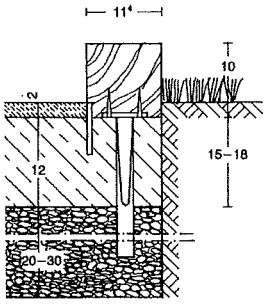
❸ Plan of discus throwing circle and cage



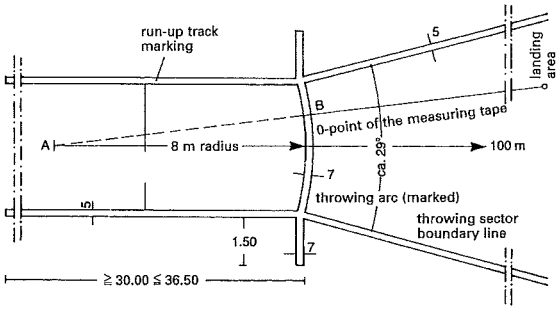
❹ Discus throwing area; discus ≧219 mm ≦221 mm (men)



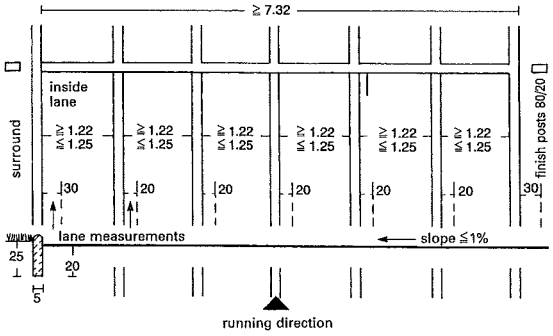
❺ Shot put circle → ❻



❻ Shot put: circle edge board, section A–B



❼ Javelin area



❽ Track dimensions, track and field type B

SPORTS FACILITIES

Athletics

The dimensions given in → ❾ are in line with the competition rules and must be observed. Deviations are possible for school sport, training and leisure sport.

Hammer throwing equipment is laid out similarly to discus equipment → ❶ – ❹, except the throwing circle has only ≧2.135 m safety cage → ❶ – ❷ for competitive facilities; otherwise, the more simply constructed safety cage, as for the discus, can be used → ❸.

Javelin facilities consist of a run-up track and a throwing sector. The width of the run-up track is 4 m, length is normally 36.5 m, but min. 30 m. The run-up track is divided from the throwing sector by a permanently marked curved throwing line.

Shot put facilities consists of a ring and a landing sector → ❺ – ❻. The normal length of shot put facilities is 20 m, for top-level sport 25 m.

The following design examples I–V for the allocation of the usable space (4 m²/inhabitant) in various catchment areas should be seen only as an orientation aid.

Example I: Sport facilities for a catchment of approx. 5000 inhabitants

1 track and field arena, type D	10,554 m²
2 small playing fields 27 × 45 m	2430 m²
1 training playing field	4500 m²
2 leisure playing fields	250 m²
1 grass play and gymnastics area	1000 m²
1 fitness area	1400 m²
total usable area	approx. 20,000 m²

Example II: approx. 7000 inhabitants

1 track and field arena, type D	10,554 m²
1 large playing field 70 × 109 m	7630 m²
2 small playing fields 27 × 45 m	2430 m²
leisure play area	3000 m²
1 grass play and gymnastics area	1000 m²
1 fitness track	2300 m²
1 roller skating track	800 m²
total usable area	approx. 28,000 m²

Example III: 7000 inhabitants

1 track and field arena, type B	14,000 m²
1 large playing field 70 × 109 m	7630 m²
3 small playing fields 27 × 45 m	3645 m²
1 grass play and gymnastics area	1000 m²
1 fitness area	1400 m²
total usable area	approx. 28,000 m²

Example IV: approx. 15,000 inhabitants

1 track and field arena, type B	14,000 m²
3 large playing fields 70 × 109 m	22,890 m²
7 small playing fields 27 × 45 m	8505 m²
leisure play area	6000 m²
1 fitness track	3300 m²
1 fitness area	1400 m²
1 fitness playing area	1000 m²
2 grass play and gymnastics areas	2000 m²
total usable area	approx. 60,000 m²

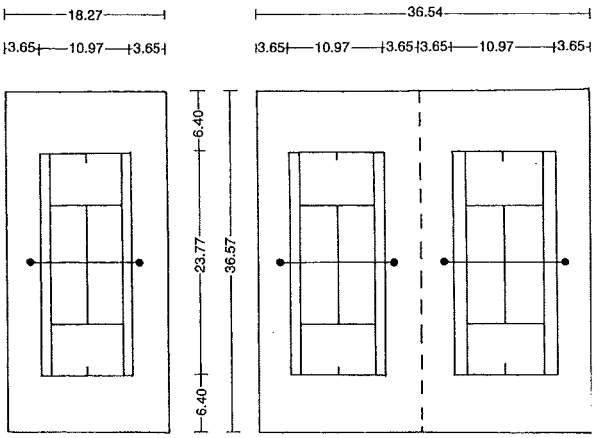
Example V: approx. 20,000 inhabitants

1 track and field arena, type B	14,000 m²
1 combined large playing field	8400 m²
4 large playing fields 70 × 109 m	30,520 m²
10 small playing fields 27 × 45 m	12,150 m²
leisure play area	6000 m²
1 fitness track	3300 m²
1 fitness area	1400 m²
1 fitness play area	1000 m²
2 grass play and gymnastics areas	2000 m²
total usable area	approx. 80,000 m²

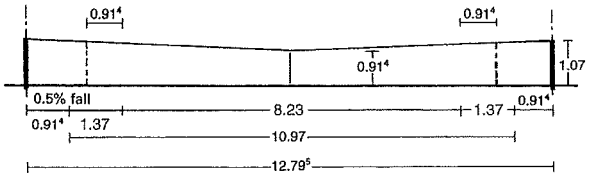
Area for sport	Throwing area (m)	Landing sector	
		Angle	Length (m)
Discus	Circle diam. = 2.50[1]	34.92°	80
Hammer	Circle diam. = 2.13	34.92°	80
Javelin	Run-up length = 36.50[2]		
	Run-up width = 4	approx. 29°	100
Shot put	Circle diam. = 2.13	34.92°	up to 25

[1] also suitable for hammer throwing with insertion of profiled ring
[2] ≧ 30 m

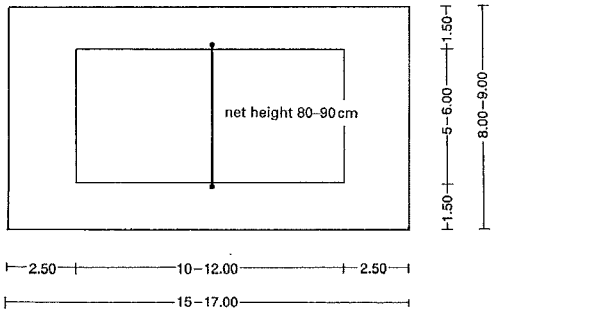
❾ Dimensions of throwing areas



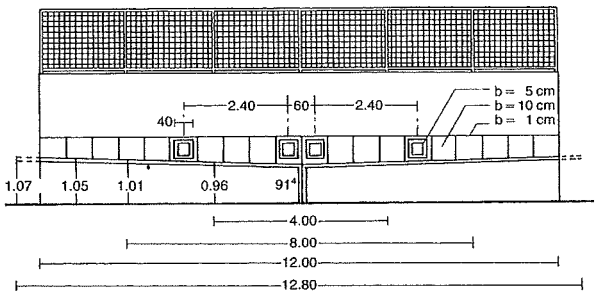
❶ Tournament courts



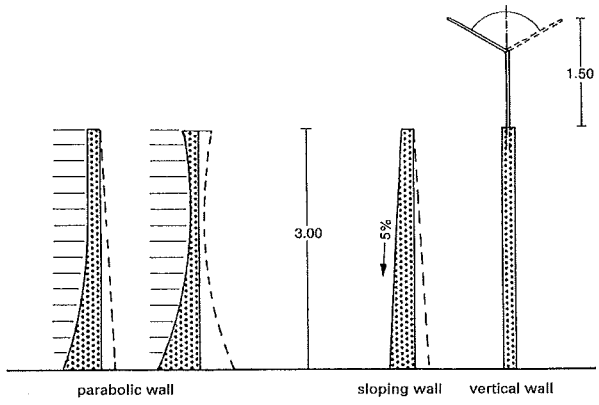
❷ The net



❸ Children's tennis court



❹ Wall marking (for serves, passing shots etc.)



❺ Types of tennis wall

Doubles court → ❶ – ❷	10.97 × 23.77 m
Singles court	8.23 × 23.77 m
Side margin	≦3.65 m
Side margin, tournament	4.00 m
Back margin	≦6.40 m
Back margin, tournament	8.00 m
Space between two courts	7.30 m
Net height in centre	0.914 m
Net height at posts	1.07 m
Perimeter fencing height	4.00 m

Fencing: 2.5 mm thick wire mesh with 4 cm mesh size.

Number of courts required:
Currently the number of active tennis players is 1.6–3% of the total population. Ratio of courts to players for new courts is 1:30; formula to determine the approximate number of courts required:

$$\text{no. courts required (T)} = \frac{\text{population} \times 3}{100 \times 30}$$

Area required for children's court → ❸.

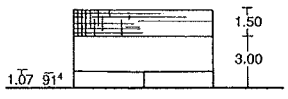
Parking places: normal tennis playing (without spectators), four vehicle parking places per court.

Plot size: net area ('usable sport area') is identical to the tennis court and the areas required for the practice wall and the children's court. Experience shows a 60–80% supplement to the net area gives the plot size. The location of the courts should be in the N–S direction if possible.

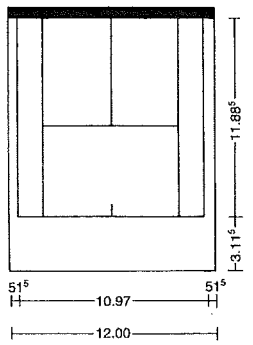
Deviations are possible (W is better than E). More than two courts next to each other is not recommended, behind each other only with visual separation. Artificial lighting at 10 m height is needed at the long sides.

The production of the space allocation plan should include later requirements for flats (caretaker, trainer, tenant) and garages from the start. The project should be designed so that building can proceed in stages without disturbing the tennis.

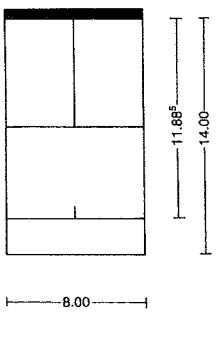
elevation → ❻



elevation → ❼



❻ Training wall (doubles): shown above are recommended dimensions for tennis walls + playing area in front of wall



❼ Training wall (singles)

SPORTS FACILITIES

Tennis

Ceiling heights for indoor tennis halls are fixed internationally. Davis Cup rules require a height of 10.67 m; recommended height 9–11 m, although 9 m will normally suffice → ❶. Tennis is also possible in gymnastics and sports halls with 7 m height. The hall height is measured from the floor, at the net, to the underside of the roof truss, and must be the same over the entire 10.97 m width of the court. The height is min. 3 m at the outer edge of the playing area. Types of halls: demountable hall, permanent hall, convertible hall. Hall internal dimensions 18.30 × 36.60 m → ❻. Because the size of the courts and the prescribed areas of the court outside the markings are fixed internationally, this gives:

tennis hall with 2 courts $\frac{\text{Te H 2}}{\text{(S + D)}}$
singles + doubles

$(2 \times 18.30) \times (1 \times 36.60) = 36.60 \times 36.60$

with 3 courts $\frac{\text{Te H 3}}{\text{(S + D)}}$

which gives analogously a hall area of 54.90 × 36.60 m. These dimensions are the ideal for sporting flexibility. If 'economical tennis halls' are planned, this makes a reduction of the built area possible but will restrict the use.

The uses are:

1. both courts suitable for singles competition
2. one court suitable for doubles competition
3. practice or leisure play on both courts, 2 singles games or 1 singles and 1 doubles.

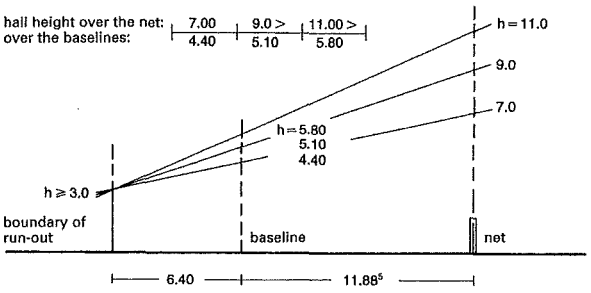
Considering the possible savings, this gives the following hall size:

$\frac{\text{Te H 2}}{\text{1 S + 1 D}}$ 32.40 × 36.60m

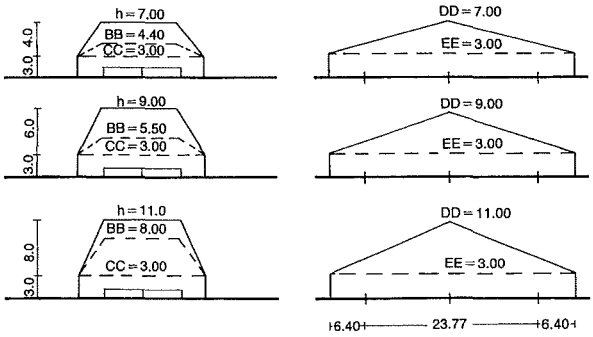
The following table shows some of the possible options:

Hall type	Courts	Singles (S)	Doubles (D)	Width	Length	Use C*	No use C*
1	1	1	1	18.30	36.60	S/D	—
2	2	2	2	36.60	36.60	2 S/2D	
2 practice	2	2	2	33.90	36.60	2 S/1 S/1 D	2 D or 2 S
3	3	3	3	54.90	36.60	3 S/3D	—
3 practice	3	3	3	49.50	36.60	3 S/2D	3 D or 3 S
2a	2	1	1	33.90	36.60	1 S/1 D	—
2a practice	2	1	1	32.40	36.60	1 S/1 D	—

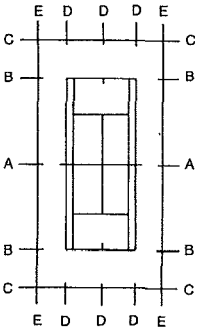
* = suitable for competition



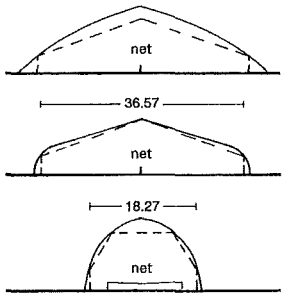
❶ Hall heights



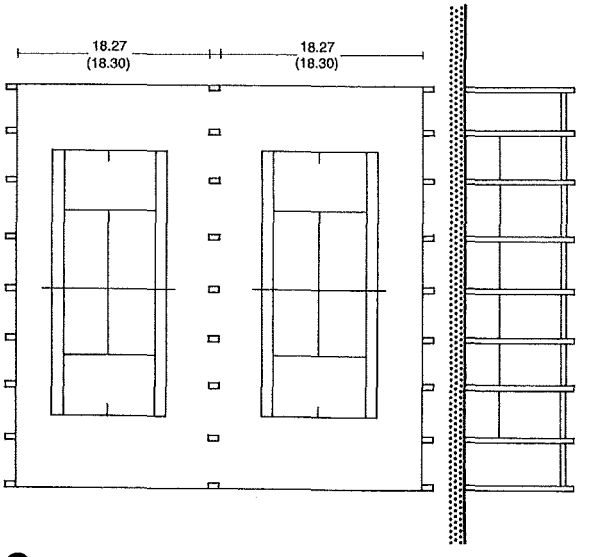
❷ Cross- and longitudinal sections of hall types hipped on the long sides → ❸



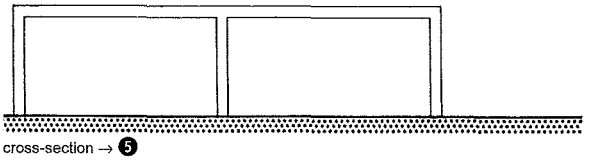
❸ Ground floor plan → ❷



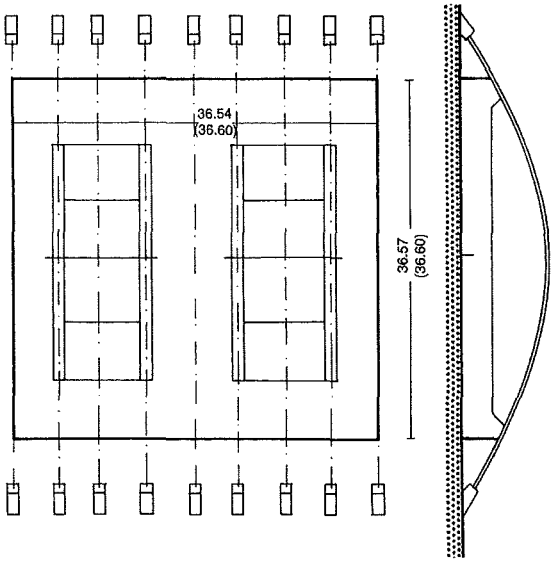
❹ Hall dimensions and forms



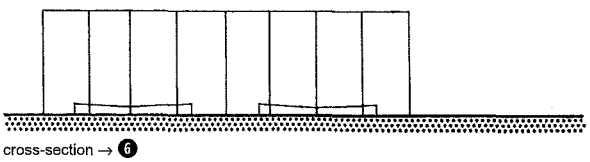
❺ Permanent hall over one or more courts



cross-section → ❺



❻ Permanent hall over one or more courts



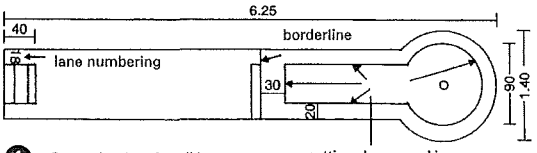
cross-section → ❻

A miniature golf course consists of 18 clearly separated lanes (exception: driving shots), which are numbered and must correspond to the standard regulations of their system. Lanes suitable for competitions have the following features:

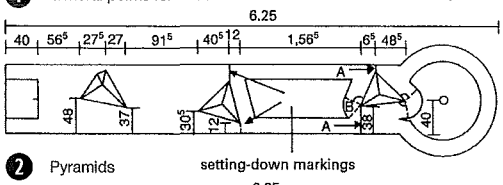
- actual playing area
- lane demarcations (mostly strips)
- tee marking
- one or more obstacles (can be omitted)
- borderline (can be omitted)
- set-down markings (can be omitted)
- hole

and perhaps further components and/or markings specific to the system.

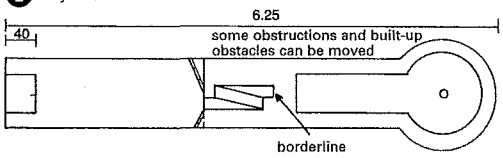
Playing area size: min. width 80 cm, min. length 5.50 m. Playing areas intended to be level must be completely flat (90 cm spirit level). In case the edges of the playing area are not determined by strips, then they must be marked otherwise (exception: driving shots). The edge strips must be so installed so that they enable a strategy to be implemented. Each lane must have a tee-off marking. The type of marking must be standardised within one course or for a certain lane system. The obstacles must be practical in construction and shape and installed permanently (according to the sporting purpose). The location of obstacles which are not fixed should be marked.



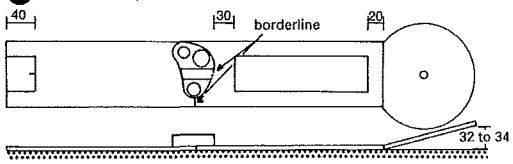
1 General points for all lanes



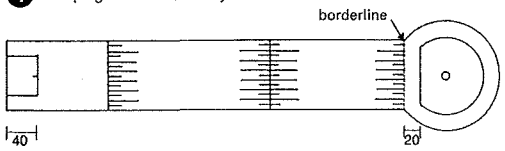
2 Pyramids



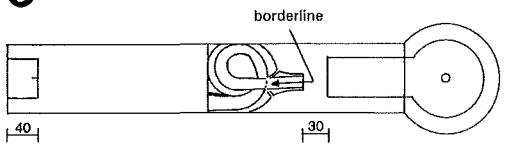
3 Somersault (with angled baffles)



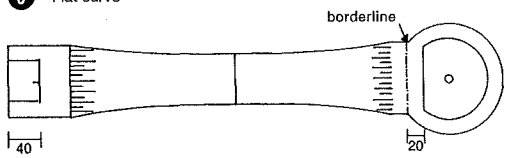
4 Sloping circle with kidney barrier



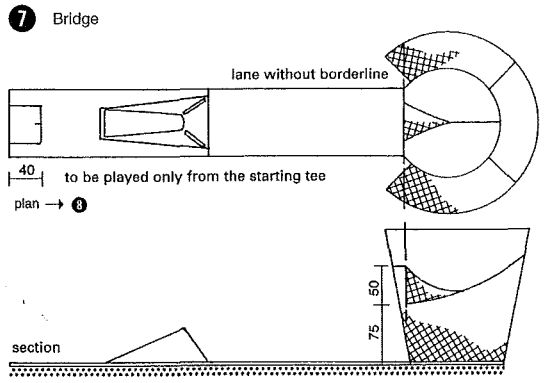
5 Floor waves



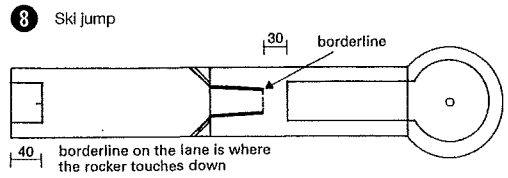
6 Flat curve



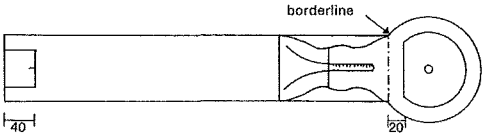
7 Bridge



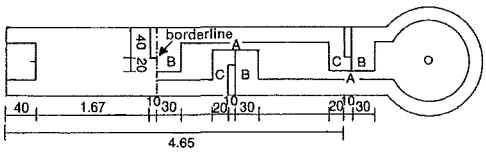
8 Ski jump



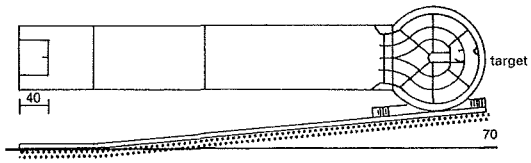
9 Rocker with hoop



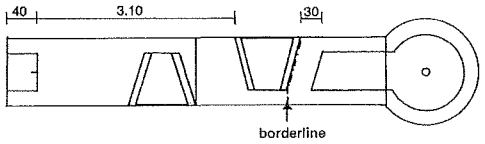
10 Pipe hill



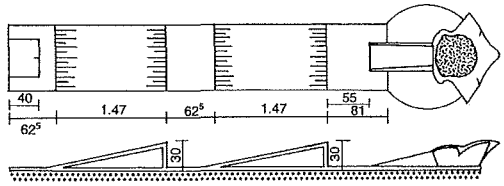
11 Straight lane with staggered obstacles



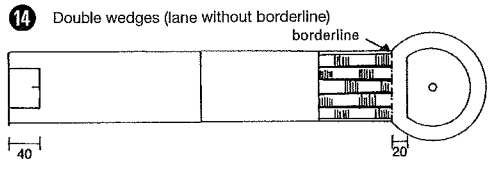
12 Labyrinth



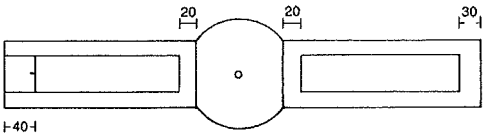
13 Blunt cone



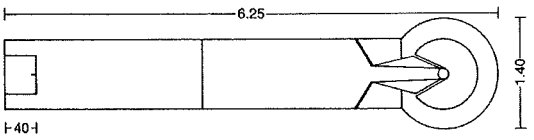
14 Double wedges (lane without borderline)



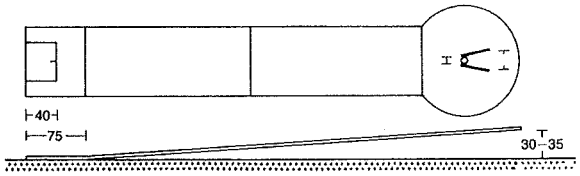
15 Irregular passages



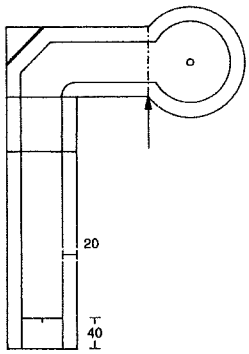
16 Central circle – lane without borderlines



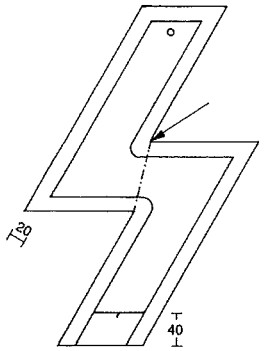
17 Volcano – lane without borderlines – only playable from the tee



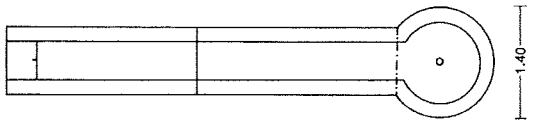
18 Steep slope with V-obstacle – lane without borderlines – only playable from the tee



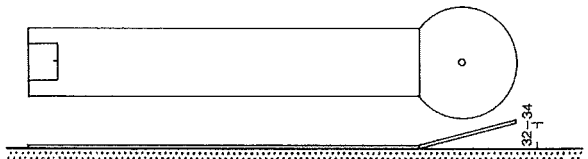
19 Right angle



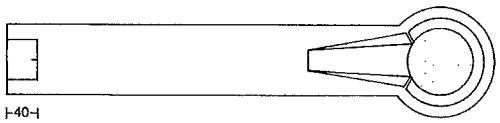
20 Lightning flash



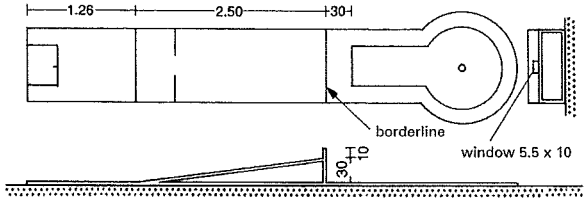
21 Straight lane without obstacles



22 Sloping circle without obstacles – lane without borderlines – only playable from the tee



23 Circular plateau – lane without borderlines – only playable from the tee



24 Run-up ramp with central opening (window)

Sport and leisure

SPORTS FACILITIES
Playing fields
Athletics
Tennis
Miniature golf
Golf courses
Water sport, marinas
Water sport, rowing and canoeing
Equestrian sport
Ski jumping
Ice rinks
Roller skating rinks
Speed roller skating, skateboarding
Cyclo-cross, BMX
Shooting ranges

Each obstacle must be different from all the others on the course, not only externally but in how they are played. A strategy must be possible.

The borderline marks the end of the first obstacles. On lanes without built-in obstacles, it shows the minimum distance the ball has to be hit from the tee in order to remain in the game. If the first obstacle takes up the entire width of the lane, then the borderline is identical with the end of the obstacle. Lanes which can only be played from the tee have no borderline. Borderline markings should be laid out so that the marking edge pointing to the tee is identical with the obstacles.

Set-down markings: when setting down or moving the ball during play is permissible, there must be markings showing where the ball may be set down.

It must be possible to reach the target from the tee marking with one stroke. If these are target holes, then the diameter may not exceed 120 mm. For the systems Minigolf, Miniaturgolf or Sterngolf, 100 mm is the limit.

Markings must be applied to all lanes. The game is played with golf clubs and golf balls. All clubs which are usual in golf, or similar objects, are permissible.

The striking area of the club head may not exceed 40 cm^2. All miniature golf and golf balls are permissible of any material. Ball diameter ≧37 mm and ≦43 mm. Balls made of wood, metal, glass, glass fibre, ivory or similar material, and also billiard balls, are not recognised as miniature golf balls.

Miniature golf lanes normally have the following standard sizes:

Lane length 6.25 m, lane width 0.90 m, target circle diameter 1.40 m → p. 329 ❶.

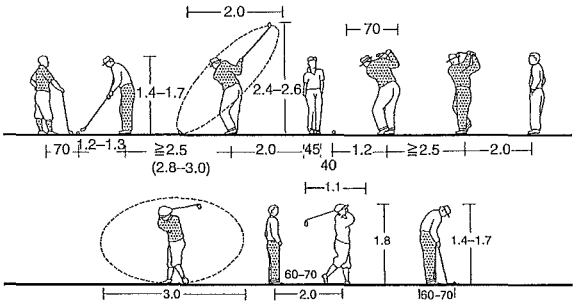
Minigolf:
Developed by the Swiss Bogni at the start of the 1950s; consists of 17 concrete pistes (12 m long) and one long piste (approx. 25 m long). The concrete pistes are surrounded by tubular steel frames. The obstacles are made of natural stone.

Cobigolf:
One of the most difficult lane systems, the 'little gates' set in front of the obstacles are a special feature. The course also consists of 18 lanes.These are in large format (12–14 m length) and also in small format (6–7 m).

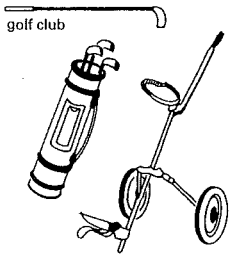
Sterngolf:
A Sterngolf course consists of 18 lanes; 17 of the concrete pistes have a semi-circular target area and the last has a star as a 'target circle'. This gives the system its name. The lane length is 8 m, lane width 1 m and end circle diameter 2 m. The lanes are bounded by pipes. The tee is marked by a circle of 30 cm diameter and the hole is 10 cm diameter.

All the obstacles are standardised for all lane golf systems, and selected and constructed according to sporting requirements. Therefore it is possible to hole every lane in one stroke, because every player of miniature golf aims to take as few strokes as possible on every lane.

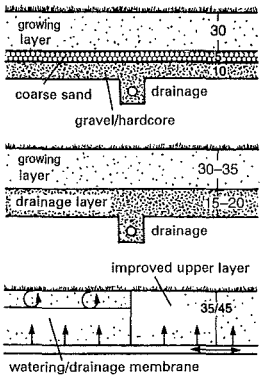
A score of 18 – every lane holed in one – has often been achieved.



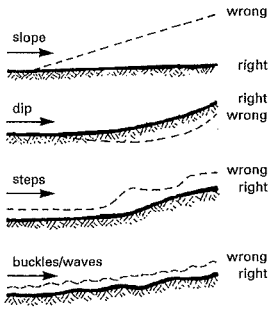
1 Space requirements for golfers



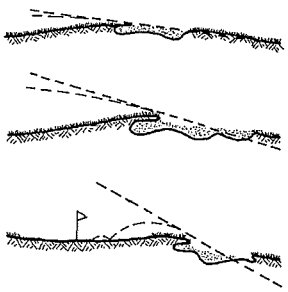
2 Golf bag with trolley



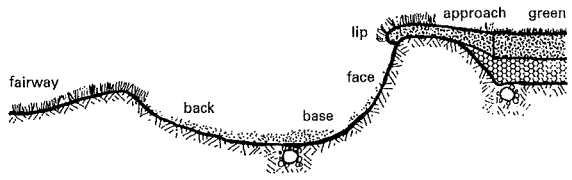
3 Construction details for types of green



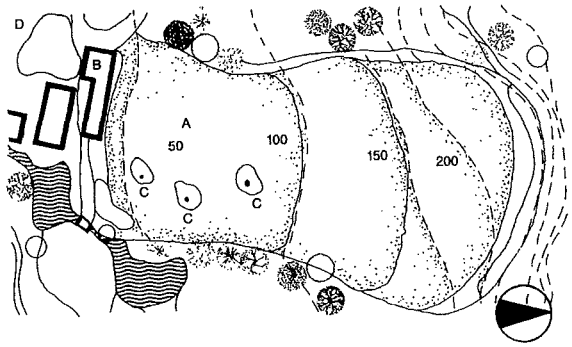
4 Surface modelling of greens



5 Bunker design, depth and shape depending on distance from green. The nearer to the green, the steeper the face



6 Section through a bunker next to a green



A Practice green
B Driving range hut
C Pitching greens
D Parking

7 Basic layout of a practice area → 9

Practice areas → 7 are used either to practise the short game or for beginners taking up golf. A golf centre as an independent sports facility can, for example, be laid out on an area of only 10 ha. This would include a practice area, an approach green, a practice green and a 9-hole golf course (par 3) → 9.

Recognised standard lengths of golf courses vary between the standard 60 with a normal length of 3749 m and the standard 74 with a normal length of 6492 m. These overall lengths of golf courses result in the 'par' score.

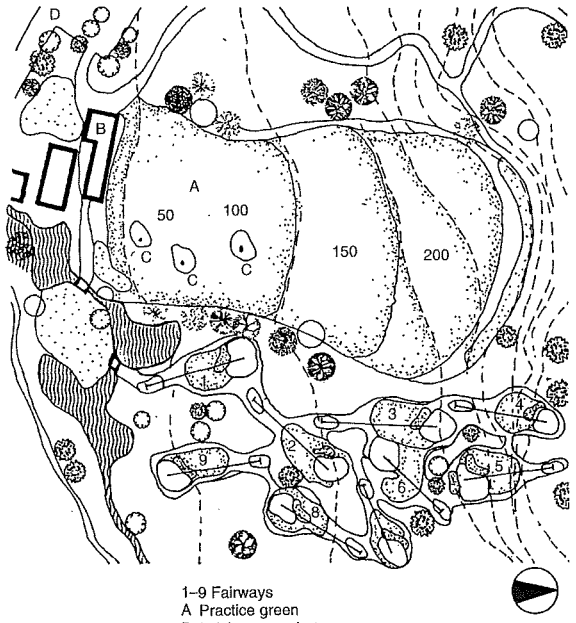
Elements of a golf course

The course starts at the tee, which has no specified size. It should be about 200 m² with adequate width. Fairways are 30–50 m wide and 100 to > 500 m long. At the end of the fairway is the green, min. 400 m², but normally 500–600 m². Aprons to the greens, which are not usual everywhere, min. width 2.5 m. Roughs are areas with growth of various heights at the edge of the fairways and over the remaining areas. Bunkers are the most common artificial obstacle, but have the disadvantage of working as foreign bodies in the landscape.

Golf courses are best situated in uneven terrain with flat slopes between wooded thickets, trees or tree groups without undergrowth, with natural hazards (watercourses, lakes), with cuttings and hillocks, or among dunes on the coast. The size of a course depends on the number of holes and their length (distance from tee to hole).

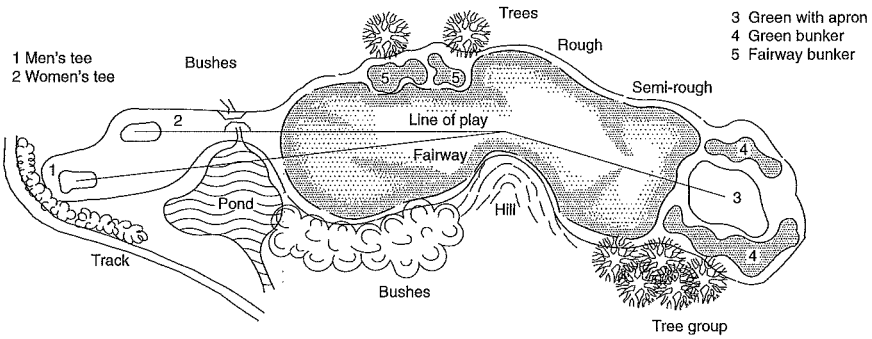
'Par'	Length of hole	
	Men	Ladies
3	up to 228 m	up to 201 m
4	229–434 m	202–382 m
5	above 435 m	above 383 m

8 Golf hole lengths

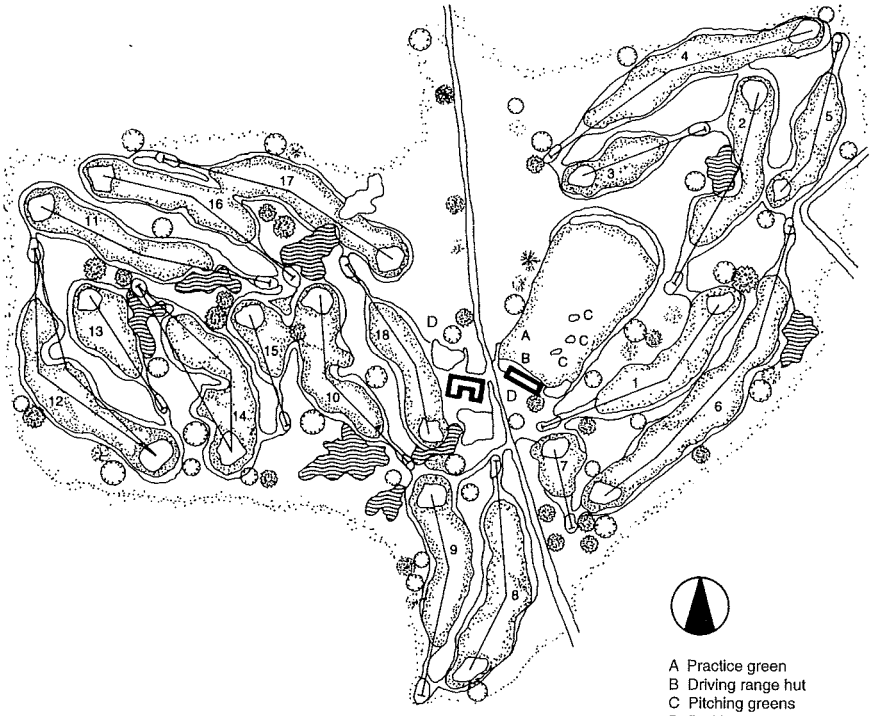


1–9 Fairways
A Practice green
B Driving range hut
C Pitching greens
D Parking

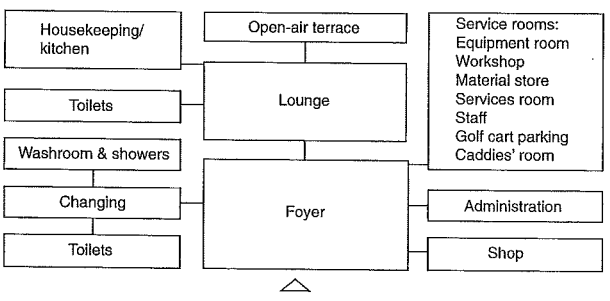
9 Extension of practice area



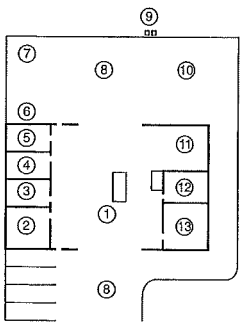
1 Elements of a golf hole



2 Example of an 18-hole course



3 Space allocation plan for a golf clubhouse



4 Functional example of a golf course utility building

Golf courses are not standardised as sports facilities and are generally unique. Nearly always today, they can be constructed only on former forest or agricultural areas. Golf course design requires the direction of a versatile expert, who needs the expertise of a landscape architect, landscape ecologist, soil scientist, cultural technician, economist etc. – and golfer. Before the actual design work can begin, background data has to be collected. Catchment area of the intended site: number of inhabitants in the area within 30 minutes by car required for a 9-hole golf course is approx. 100 000, in order to achieve a sufficient number, about 300, members of a golf club.

An important part of a golf club is the practice area, which comprises a grass area, a practice green and an approach green → p. 331 ❼. Grass practice areas should be as flat as possible with a width of min. 80 m in order to provide practice space for about 15 golfers simultaneously. The length should be min. 200 m (better 225 m) and arranged so that neighbouring holes are not disturbed. The ideal location is near the clubhouse. Approach greens should have a minimum area of 300 m^2 and be shaped. A sand trap for practice strokes should be min. 200 m^2 and have various depths.

The design of a golf course should generally assume that the completed facility will provide an 18-hole course, which means sufficient land of min. 55 ha (better 60 ha) must be available in the longer term. In order to offer the alternative of a half round (9 holes) on an 18-hole golf course, the 1st tee, 9th green, 10th tee and 18th green should all be within reasonable distance of the clubhouse if possible → ❷.

Boat types

Competitive races are possible only if every competitor has the same equipment. This has led to mostly standardised types of boats competing in sailing regattas. National classes are recognised by national ruling bodies and international classes by the International Sailing Federation in London. This also regulates the Olympic classes, which are newly specified after each Games (→ ❽ Examples of sailing boat classes and dimensions).

The depth of water required in harbours, marinas and watercourses depends on the type of boat. Usually specified are 1.25 m (dinghies, centreboard boats) and 4–5 m (keelboats) depth of water. Uniform water levels are favourable for the construction of harbours and safety of the boats.

Sailing boat type/class (crew) (1–3)	Unitary (U) or constructed (C) class	Size – length/width (m)	Draught (m)	Sail area 3 – S = spinnaker (m^2)	Distinguishing mark on sail
internat. classes:					
Finn dinghy[1] (1)	U	4.50/1.51	0.85	10	two blue wavy lines above one another
Flying Dutchman (2)	U	6.05/1.80	1.10	15 (S)	black letters FD
Star[1] (2)	U	6.90/1.70	1.00	26	five-pointed red star
Tempest	U	6.69/2.00	1.13	22.93 (S)	black letter T
Dragon (3)	U	8.90/1.90	1.20	22 (S)	black letter D
Soling (3)	U	8.15/1.90	1.30	24.3 (S)	black letter Ω (Omega)
Tornado[1](2)	U	6.25/3.05	0.80	22.5 (S)	black letter T with two parallel underlinings
470[1](2)	U	4.70/1.58	1.05	10.66 (S)	black number 470
5.50-m yacht	C	9.50/1.95	1.35	28.8	black number 5.5
Yngling[1](2)	U	6.35/1.75	1.05	14	black letter Y
49er[1](2)	U	4.99/1.7(2.9)	1.50	21.2 (S)	black number 49er
Pirate (2)	U	5.00/1.62	0.85 +	10 (S)	red axe
Optimist (1)	U	2.30/1.13	0.77 +	3.33	black letter O
children & junior cadet (2)	U	3.32/1.27	0.74 +	5.10 (S)	black letter G
OK dinghy(1)	U	4.00/1.42	0.95	8.50	blue letter O and K
Olympia dinghy (2)	U	5.00/1.66	1.06 +	10	red ring
420 dinghy (2)	U	4.20/1.50	0.95 +	10 (S)	black number 420 sloping and staggered
some national classes:					
15 m^2 Wanderjolle or H-boat (2)	C	6.20/1.70	—	15 (S)	black letter H
15 m^2 dinghy cruiser (2)	C	6.50/1.85	—	15 (S)	black letter P
20 m^2 dinghy cruiser	C	7.75/2.15	—	20 (S)	black letter R

[1] Olympic classes + with lowered centreboard

❶ Dinghy

❷ Open keelboat

❸ Open catamaran

❹ Keelboat cruiser

❺ Keel cruiser

❻ Bilgeboard cruiser

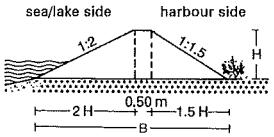
❼ Inflatable boat

❽ Examples of sailing boat classes and dimensions

❾ Motor cruiser

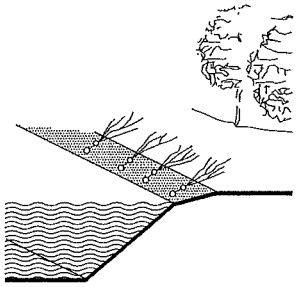
❿ Classic boat

⓫ Motor yacht

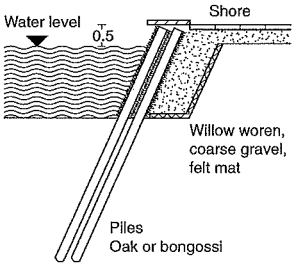


height H (m)	base width B (m)
1	4.00
2	7.50
3	11.00
4	14.50
5	18.00
6	21.50

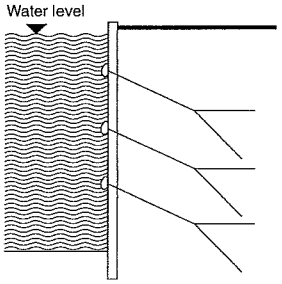
❶ Sections of moles and seawalls



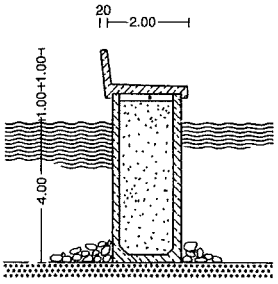
❷ Reeds with at least two layers of vegetation



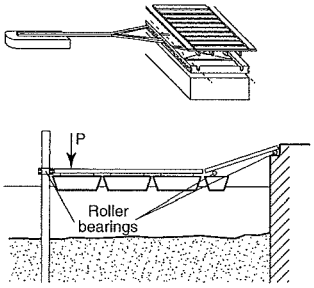
❸ Rammed timber piles



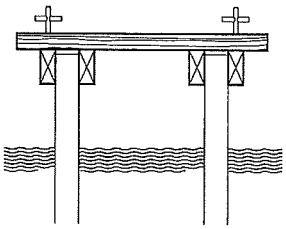
❹ Sheet steel pile wall



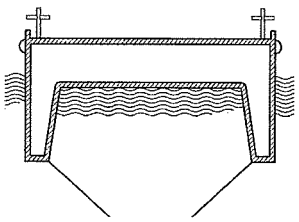
❺ Pre-cast concrete caisson with sand filling



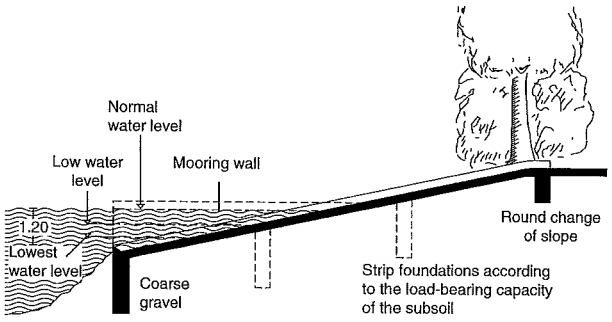
❻ Section through floating pontoon, edge loading P min. 2.5 kN



❼ Fixed quay of timber or concrete piles



❽ Floating concrete pontoon, suitable as a breakwater



❾ Section through slipway

Marine engineering works

Structures protecting against wave impact, suction and swell are important for every marina.

Breakwaters (or **moles**) are formed of rammed sheet piles or stone boulders → ❷ – ❹. Concrete caissons can be used only in relatively shallow water. → ❺ Floating piers consisting of concrete pontoons are also possible. → ❽ Breakwaters should permit pedestrian access for sightseeing.

Sheet pile walls offer permanent coastal protection with the least use of space. They normally consist of rolled steel profiles with vertical interlocking, but can also be of timber or plastic. A sheet pile wall is nearly watertight and, because of the great resistance of heavy sheet pile in place, can bridge large spans. Sporting boats, which are tied up against a sheet pile wall, must be protected against mechanical damage with fenders. Steel pile walls can also rust, which does not look good in a marina. → ❹

Dolphins consist of steel pipes, sometimes filled with concrete or timber. Min. length 3 × water depth, depending on the seabed. Boats and quays are fixed to dolphins. The average lifetime of timber dolphins in seawater is 15 years and of steel pipes 35 years. Because this lifetime varies greatly with location, information should be sought locally.

Banks stabilise coasts and are formed by rubble, concrete or planting. Slopes depend on the height, ground conditions and detailing. → ❷ + ❸

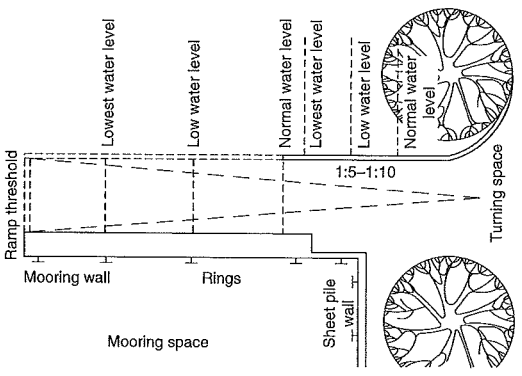
Slipways and cranes

Boat cranes can be permanently mounted in the service wharf area or else be mobile cranes. This requires load-bearing ground and sufficient space for landside access (car with trailer + truck), according to the size of the crane and the boat. The coastal protection at this location will have to be vertical.

A **travellift** is a mobile lifting device for transporting boats in the marina. → p. 335 ❾

Slipways are ramps for launching boats. Smaller and lighter boats can be launched on a trailer, but larger ones will require the trailer to be towed. → ❾ – ❿

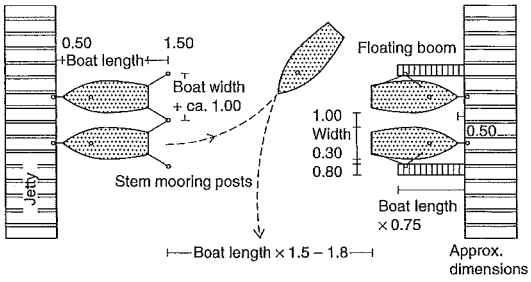
Construction materials and details for marine works are exposed to attack by the sea and should be made of stable, durable and lasting materials. Corrosion is considerable in water, especially seawater. Buildings should be sealed against wind and spray, and insulated for thermal protection in summer and winter.



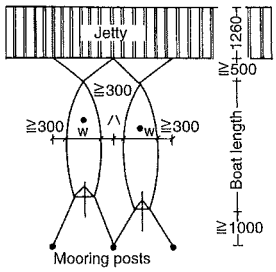
❿ Plan → ❾

Sport and leisure

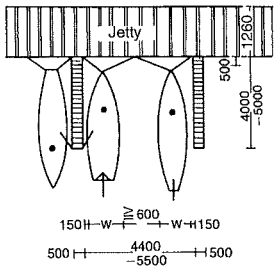
SPORTS FACILITIES
Playing fields
Athletics
Tennis
Miniature golf
Golf courses
Water sport, marinas
Water sport, rowing and canoeing
Equestrian sport
Ski jumping
Ice rinks
Roller skating rinks
Speed roller skating, skateboarding
Cyclo-cross, BMX
Shooting ranges



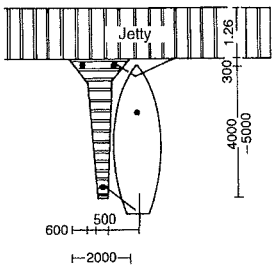
❶ Manoeuvring between quays



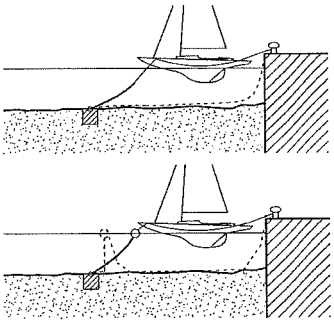
❷ Mooring a boat: mooring between quay and posts



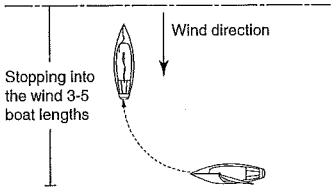
❸ Mooring a boat: diagonal boat mooring; quay and outrigger



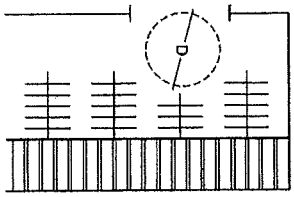
❹ Mooring a boat: mooring a boat between quay and outrigger in a Y-shape



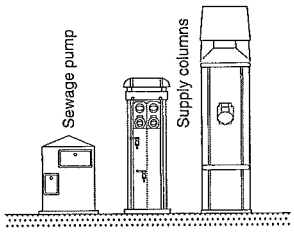
❺ Mooring with and without buoy



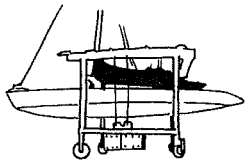
❻ Manoeuvring space for stopping under sail



❼ Right-angled harbour



❽ Toilet, bilge and foul water, electricity and water supply, cable TV and Internet connection



❾ Travellift for land transport and rapid launching

Design of moorings

Berths should always be aligned to the wind, with the size of berths appropriate to the type of boat and how the boat is moored (bow or stern). If sailing boats without motors are to be expected (a regatta harbour), there should be sufficient space for manoeuvring to halt the boats. Sailing boats stop by running into the wind, which can take 2–5 boat lengths according to type → ❻.

Behind the harbour mouth, there should be a turning circle to allow the largest ship to turn. This turning circle, ~35–60 m diameter, is necessary to enter the harbour safely and for manoeuvring in a storm → ❼.

Quays

The choice of type of quay is determined by the strain from the load, ship impact and hawser tension.

Fixed quays on rammed piles are endangered by high tides. → p. 354 ❼

Modern **floating quays** are fixed to mooring posts or anchored, and enable safe and controllable docking at any water level. → p. 354 ❻

Berthing at a mooring is normal in southern waters → ❺

The water depth at the mooring place should be min. 1.8 times the deepest draught. The berth should be provided with electricity and water and a drainage connection. Tying-up equipment like bollards, clamps or rings of adequate size is needed. Slip-resistant surfaces and planking of quays are necessary, as are a handrail on one or both sides and lighting for the quays and berths.

Provide waste containers of sufficient number and size (rubbish separation!).

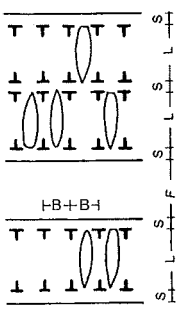
Size of berths

The size of berths depends on the boats in the marina. Berths of various sizes should be offered, ideally sorted according to size. A few berths for superyachts (length over 21 m) are also necessary. Manoeuvring and tying up at the berths should be safe.

Dry storage marina

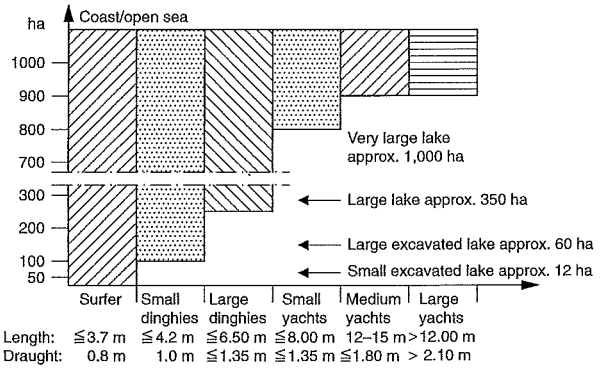
If there is too little space available on the water, boats can be stored on shore and transported by a travellift to be launched in max. 30 min. The dry storage marina is equipped with quays and berths on land so that the use of the boat is also possible on land (water, drainage and electricity connections). The ratio of land to water in such a marina is about 80:20.

The investment costs are only about 40% of a comparable conventional marina.

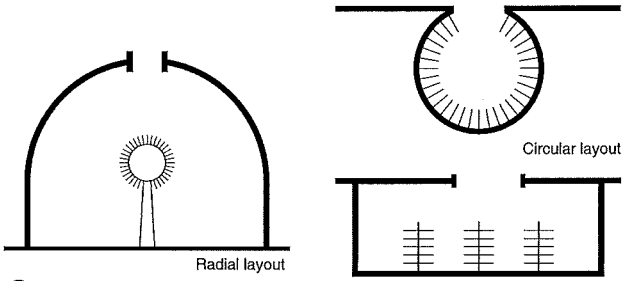


Boat class	Required berth size (m)		Safety spacing (m)	Passage width (m)
	length (L)	width (W)	(S)	(P)
Finn dinghy	4.50	3.00	3.00	5.00
Flying Dutchman	6.00	3.00	1.00	6.50
Star	7.00	3.50	1.50	7.50
Tempest	6.70	4.00	2.00	8.00
Dragon	9.00	4.00	2.00	9.50
Soling	8.50	4.00	2.00	9.50
Tornado	6.50	6.00	2.00	7.00
470	5.50	3.50	1.50	5.00
S safety spacing in front of and behind the berth length L				

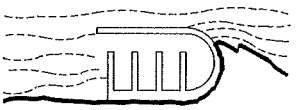
❿ Sizes of berths on land for Olympic sailing boat classes



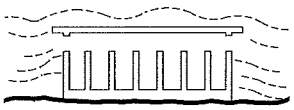
❶ Relationship – extent of water : boat size



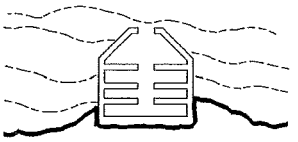
❷ Arrangement of berths



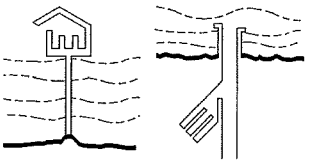
❸ Breakwater closed on one side



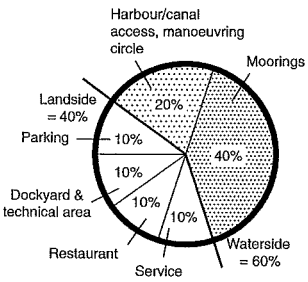
❹ Open breakwater parallel to the shore



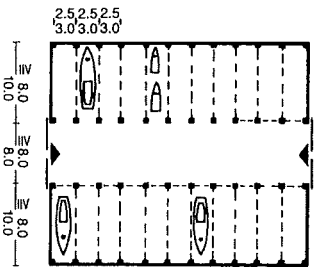
❺ Funnel-shaped breakwaters



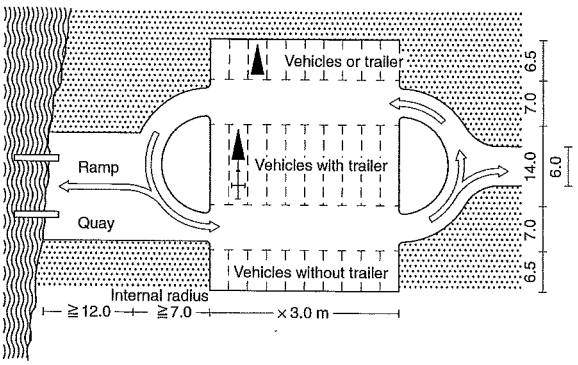
❻ Island and river mouth



❼ Area distribution of a marina – land:water approx 1:1.5



❽ Boat storage hall scheme, doors facing stern side



❾ Land storage places

Sport and leisure

SPORTS FACILITIES
Playing fields
Athletics
Tennis
Miniature golf
Golf courses
Water sport, marinas
Water sport, rowing and canoeing
Equestrian sport
Ski jumping
Ice rinks
Roller skating rinks
Speed roller skating, skateboarding
Cyclo-cross, BMX
Shooting ranges

The first stage of designing a marina is a feasibility study and various approvals on land and water. A marina is always intended for leisure and tourism. The specialisation trends for marinas are fitting-out marina, event marina, berth marina, mini-marina, dry store marina etc. → p. 337.

Selection of location

The boats must be protected. Access by water and by road on land must be guaranteed. Marinas should ideally not be built in open countryside but rather in connection with leisure, urban or tourist attractions.

Size and capacities of marinas

There should be a minimum depth of water to suit the intended sporting boats. Avoid sporting and ecological conflicts and overloading on the water. On average, only 33% of the marina's boats will be on the water at the same time. Consider the simultaneity factor (describes the ratio of the total permitted number of boats to the average number of boats underway), determination of the technical space requirements for individual types of boats, and sufficient spacing from other boats.

Organisation of areas

Mooring area: toilet pump, lifebelts, supply columns for electricity, water, waste disposal; this area should be safe, attractive and functional → p. 335. **Technical area:** slip ramp, crane, chandler, workshop, motor service, repair area (consider emissions and influence of pollution). **Restaurant area:** with terrace overlooking the water. **Service area:** harbour master, showers, toilets, information (must be easy to find). **Parking:** safe and easily accessible for cars and trailers → ❾.

Layouts

Right-angled harbour → ❸: mainly for medium-sized marinas (100–400 berths), long major breakwater running parallel to the shore, closed at one end; alignment to the main wind direction and to waves must be considered.

Open breakwater parallel to the shore → ❹: the breakwater is not accessible and offers only limited protection, as the harbour is open on two sides. It is suitable only for shores without sediment deposition, but can be used for inland waters. Disadvantage: reflection of the waves from the shore through the harbour against the inside of the breakwater.

Enclosing breakwaters → ❺: two breakwaters run from the shore and form a funnel-shaped harbour entrance. This is very expensive to construct and suitable only for locations with the best possible natural conditions – the ideal type for a protected coastal marina.

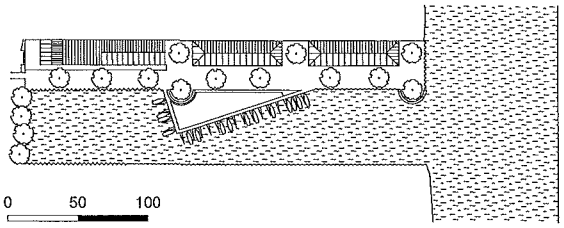
Island harbour → ❻: with sensitive shores, if water depth is insufficient or space is a problem. According to local conditions, an island marina can be piled or constructed on pontoons.

Land storage of boats

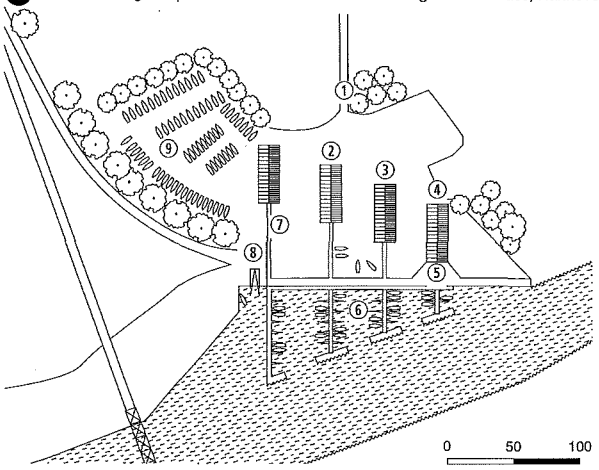
Larger boats are stored in sheds or in the open air over the winter. Storage should be safe against storms if on blocks and jack stands, with sufficient safety spacing between boats → ❽.

Open areas and roads in marinas must be adequate for boat transport and storage. The car park should have an associated lockable place for trailers.

Turning areas should be sufficiently large for vehicles with trailers and cranes and in front of slipways, diameter min. 18 m, and load-bearing (min. 6 t axle load). In large marinas, these areas should be concrete or asphalt surfaced. → ❾

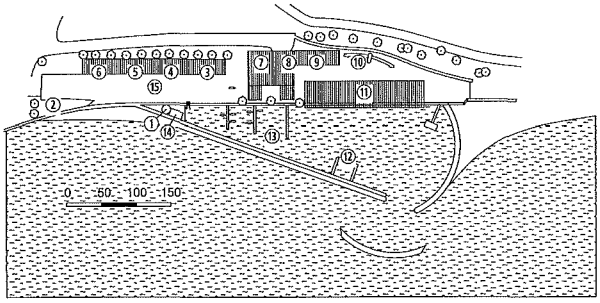


❶ Water touring rest place — Design: Arch. Haass, Hannover



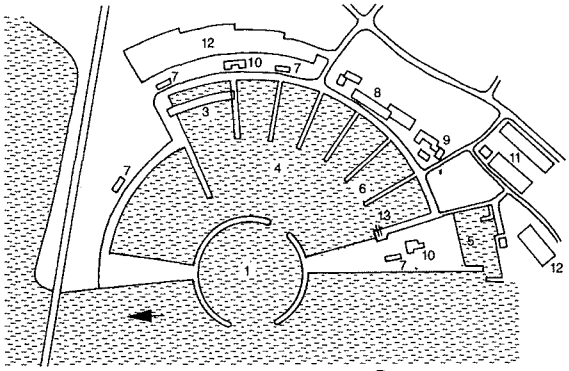
① Access road
② Reception
③ Charter area
④ Newsagent
⑤ Catering
⑥ Moorings
⑦ Boat service, workshop
⑧ Slip, crane, travellift
⑨ Land storage

❷ Dry marina on a creek — Design: Arch. Haass, Hannover



① Olympic fire
② Helipad
③ Competition office
④ VIP lounge
⑤ Teams' sanitary facs
⑥ Press
⑦ Info. & communications
⑧ Multi-stone car park
⑨ Workshop, surveying
⑩ Weather station & first aid
⑪ Land storage
⑫ Moorings
⑬ Moorings
⑭ Surfers' hall
⑮ Mixed area

❸ Olympic sailing harbour at Travemünde — Design: Arch. Haass, Hannover



① Harbour entry
② Dinghy ramp
③ Boats
④ New harbour
⑤ Old harbour
⑥ Moorings
⑦ WC
⑧ Hotel & restaurant
⑨ Shopping centre
⑩ Kiosk
⑪ Boatyard
⑫ Winter storage for boats
⑬ Travellift

❹ Example of a yacht harbour

Marina types

Day marina: floating location; only for daily mooring of boats on the coast as a floating marina.

City marina/Mini-marina/Water touring rest place: → ❶ in attractive urban location, only for overnight stays by boating tourists, minimal service.

Event marina: urban location; only intended for boating tourists visiting events, temporary and with minimal service.

Regatta and Olympic marinas: → ❸ Olympic flame, helicopter pad, workshop/verification hall, weather station, medical care and doping testing, organisation and competition office, security, VIP lounge, press boxes, cranes, washing area. Berths: Star and Yngling. Land storage area: 49er, Tornado, 470, Laser, Finn, Europe Star and Yngling (all including container storage), surfer hall. Shuttle jetty, changing rooms/sanitary facilities/WCs for the teams, information and communications centre (for team meetings, official committee, competition transmission for participants, bistro). Parking, mooring for trainers' boats, moorings, mixed area.

Berth marina: location at the edge of town is possible, only water berths without additional service. Suitable for clubs and associations.

Tourist marina: harbour office, berths, sanitary facilities, chandler, restaurant.

Association and club marinas: club house, terrace, car parking, access, jetties, berths, land storage space, repair/workshop.

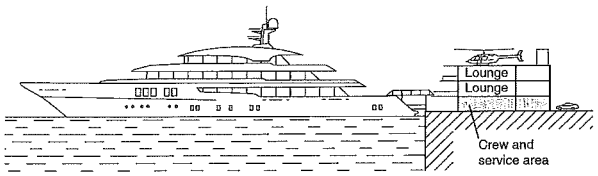
Dry marina: → ❷ location at the edge of town or industrial estate, predominantly land storage with well-functioning travellift launching of boats. Service, facilities, minimal space on water.

Technical marina: possible location on industrial estate; only technical services like crane, repair, winter service, boat building, refitting etc.

Winter marina: possible location on industrial estate; only winter storage of boats in sheds or the open air. Observe sufficient space between boats and possibly separate storage areas for equipment and working materials (fire hazard from paint and varnish).

Task/function	Requirements	Construction
1. Transport areas for trailers and towing vehicles, etc.	– sufficient width – turning space for towing vehicles – sufficiently loadbearing – surface drainage	– frostsafe construction – drainage – solid surfacing of concrete, asphalt or similar
2. Land areas for boats	– sufficient size – sufficiently loadbearing – anchorage for tarpaulins	– frostsafe construction – waterbound surfacing – founded anchorages, e.g. rings
3. Access roads for emergency services	– width according to RAST – sufficiently loadbearing – turning circles for vehicles – surface drainage	– frostsafe construction – drainage – surfacing of paving, concrete, asphalt or similar
4. Parking for vehicles	– sufficient space – sufficiently loadbearing – clear marking of places	– waterbound surfacing – paving strips to mark spaces – frostsafe construction
5. Footpaths and cycle ways	– width 1.5–2.5 m – separated from vehicles – safe and clearly laid out – surface drainage	– frostsafe construction – waterbound surfacing or paving – drainage

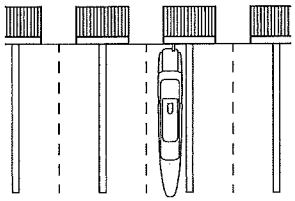
❺ Roads and car parks: functions and construction quality



❶ Superyacht marina, section showing separation into crew and owner areas
Arch.: Haass, Hannover

size of yachts	10–21 m	30–80 ft
small superyachts	21–30 m	80–100 ft
medium superyachts	30–60 m	100–200 ft
large superyachts	over 60 m	over 200 ft

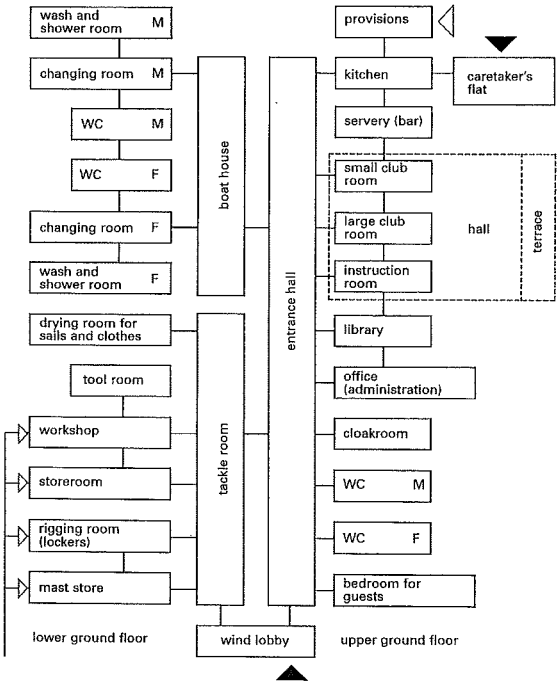
❷ Superyacht categories according to size



❸ Theoretical sketch of a superyacht marina with service building and lounge

Medium	Connection on board	Capacity
Electricity		Operated by crew
Fresh water		min. 50 l / min Operated by crew
Waste-water		Pump-out station Operated by crew
Fuel		Diesel / petrol operated by marina

❹ Requirements and usual location of the utility aspects of superyachts



❺ Functional scheme of club house

Superyacht marinas

Yachts of more than 21 m/70 ft length are described as superyachts. From a length of more than 30 m, these yachts have professional crews. Such yachts require particular attention in the design of a marina, either as an extension of an existing marina or as an independent marina.

The location can only be exclusive with high-quality tourist attractions, and connection to an airport and a major city. The superyacht business in Europe is mostly concentrated in the Mediterranean.

Superyachts require extensive space for berths ❶ – ❸ and have heavy utility requirements ❹. Water depths of min. 8–9 m are required.

The concept of a superyacht marina corresponds to the requirements of a 5-star hotel, with 24-hour service for technical support and a personal reception service. Zoning is similar to a 5-star hotel, plus separated areas for crew and service → ❺. The security of ships and crews need to be ensured through appropriate facilities. 24-hour security service, video surveillance and electronic access control systems, as well as the lighting of the most significant areas of the marina, are important.

Security in marinas

Security facilities in marinas protect boats, equipment (electronics) and people from the forces of nature and criminality, vandalism and terror.

Active measures:
Arrangement, visibility of berth areas
Alarm systems on boats
Security for berths, jetties (gates)
Passive measures:
Video surveillance of berths
Lighting of the marina
Security service, security patrols
Emergency measures, security plan
Security management

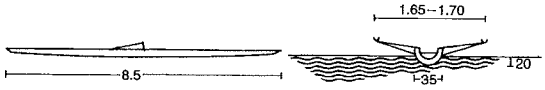
Marinas inside waterfronts with public access require a lockable central area (harbour office) and additional 24-hour surveillance. The marina should be marked with notices and rules, which can be implemented as marina regulations and enforced by police.

Each marina requires an emergency plan, which provides the greatest possible safety in an emergency, with employee instruction and training. Training days should be carried out at least twice a year.

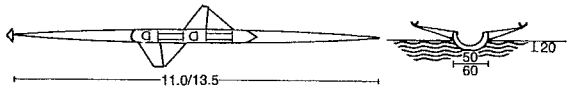
Sustainability

Environmental technologies can be implemented in marinas to save energy, but also for the exploitation of alternative energy: geothermal, wind power, waterpower, photovoltaic, solar heating etc. can all be employed in marinas. A good marina should function without external energy supply. An environmentally friendly marina protects water and subsoil through the use of environmentally safe materials (no water pollution).

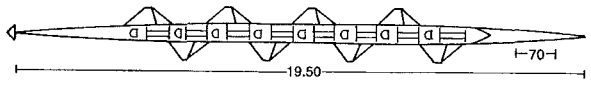
Environmental acceptability is achieved through concentrating the marina equipment and technology into functional areas, which can be switched off in the winter – energy zones and levels of operational intensity. Public transport instead of shuttle/taxi service, energy-saving times (e.g. 24:00–6:00), price levels according to energy use etc.



❶ Racing shell: single

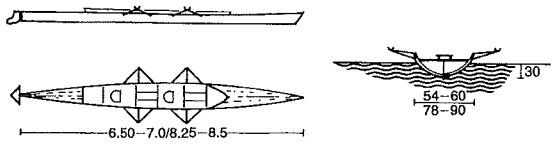


❷ Coxless pair / four

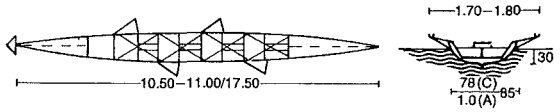


❸ Racing shell: eight

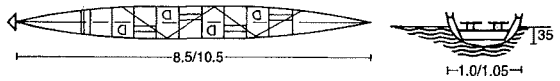
❹ Racing skiff: single/four/eight



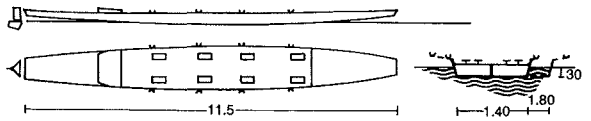
❺ Touring skiff: single/pair



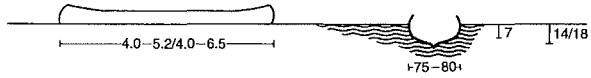
❻ Touring skiff: four/eight



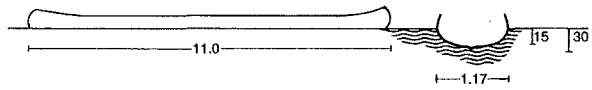
❼ Seagoing gig: pair/four



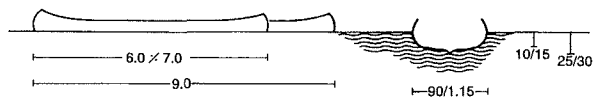
❽ Touring boat



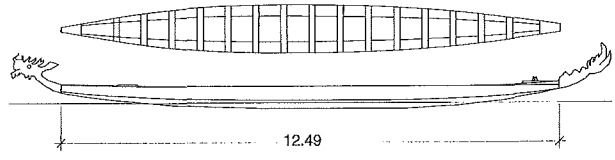
❾ Canoe with single-bladed paddle



❿ Racing canoe: eight with cox



⓫ Touring crew canoe: eight and ten with cox



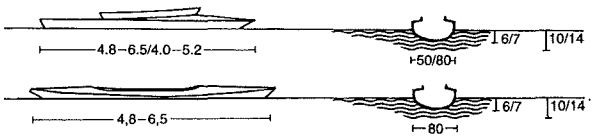
⓬ Dragon boat, IDBF racing standard

Rowing boats are predominantly team boats belonging to clubs. Like kayaks and canoes, they are mostly found on flowing waterways which are free of obstacles, in attractive countryside.

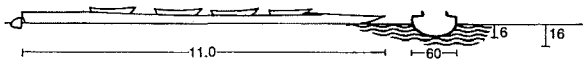
A boathouse has windows or skylights to the north, in order to keep sun out. Doors ≧2.50 × 2.75 m, to carry boats in above the head. Boathouse width ≧6.00 m, length ideally 30 m, height 4.0 m if possible → ⓯. Oars 3.80 m long, spoons 15–18 cm. Storage near the entrance, horizontally on racks or, better, hanging from a clamping ring above a pit (depending on boathouse height).

Between boathouse and water jetty, a shore strip ≧20–30 m wide is required for cleaning and preparing the boats, with water taps and parking space for trailers. If possible, provide nearby lawn or woodland areas for camping.

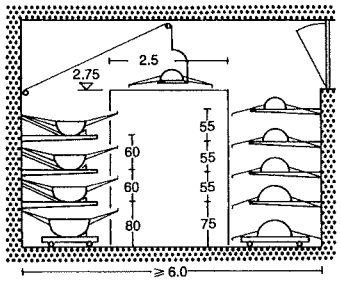
Rowing basin for training with shortened oars → ⓱, basin size for an eight 12.60 × 7.60 m. Single or double-sided rowing basin (also offset). Water circulation creates similar currents to open water. Ideally, this facility should be combined with a sports hall or indoor pool and their changing rooms.



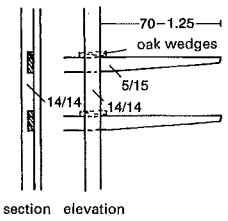
⓭ Kayak with double-bladed paddle: single/pair



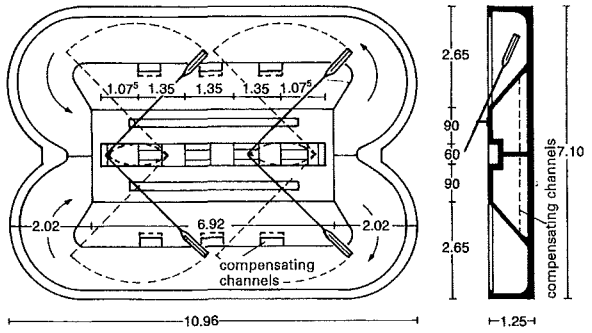
⓮ Kayak with double-bladed paddle: four



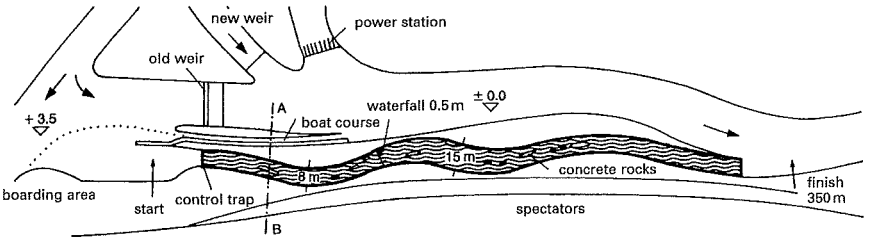
⓯ Section through boathouse



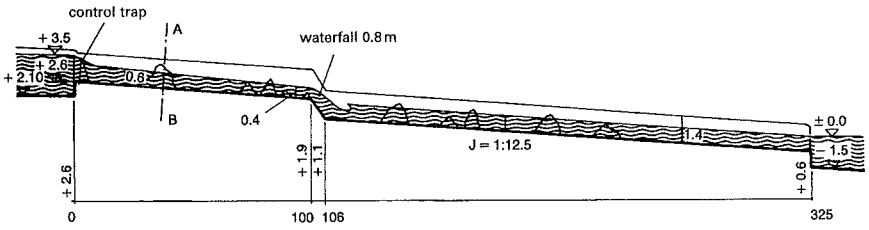
⓰ Boat stands every 2.00–2.50 m



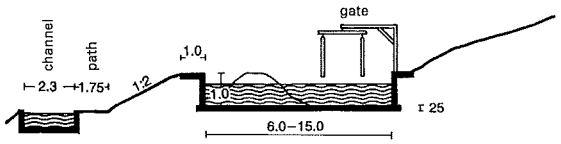
⓱ Double-sided sculling pool



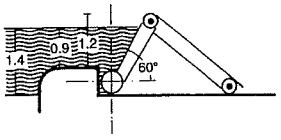
❶ Regatta course for canoe slalom



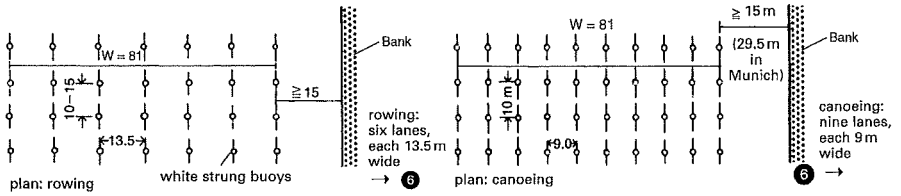
❷ Horizontal section → ❶



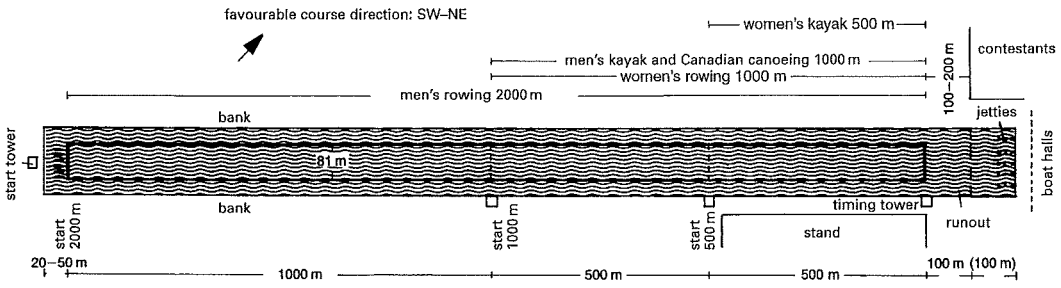
❸ Cross-section → ❶



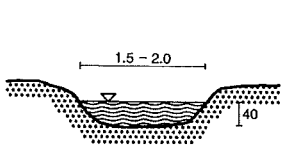
❹ Control trap with draining base



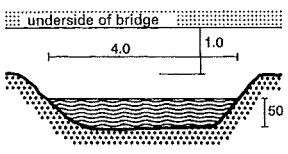
❺ Track markings (international dimensions) for competitive rowing and canoeing



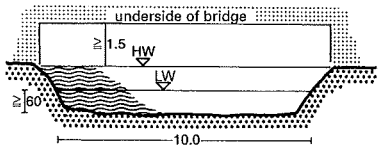
❻ Regatta course in Munich (international dimensions) for competitive rowing and canoeing



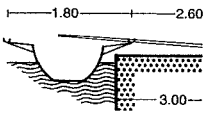
❼ Waterway for touring, 1000 l/min.



❽ Waterway for touring, normal



❾ Waterway



❿ Jetty, min. length ≧7.0 m

Requirements for regatta and training courses for canoe and slalom:

1. Natural facilities: In steep sections (min. 1:100 gradient) of waterways not suitable for normal boating traffic or similar rivers with min. 10 m^3/s flow (at mean low water or as controlled by an upstream weir). Also in tailwater from mills and power stations, min. 8 m wide, with and without obstacles (installation of gates) → ❸

2. Artificial facilities: Olympic course in the Eiskanal/Lech near Augsburg, 550 m long. Reinforced concrete channel with concrete rock obstacles and 6 m falls, invert waterfall, up to 32 gates.

Requirements for regatta and training courses for competitive international rowing and canoeing → ❺.

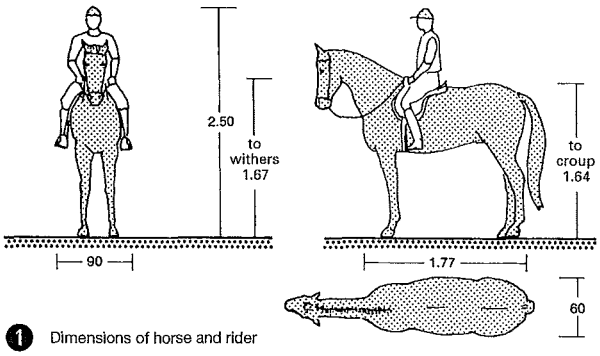
Minimum requirements for water touring courses → ❼ – ❿. Criteria for water touring rest places and canoe stations are laid down by the DKV (German Canoe Association). See also p. 337.

Riding facilities/stables should, if possible, be in the immediate vicinity of land suitable for riding. Areas with high ground and air humidity, as are often found in valleys, should be avoided, as should windless locations, where providing the desired ventilation may be difficult. Ideal sites are in hilly and windy areas. However, slope gradients for buildings and riding arenas should be <10%.

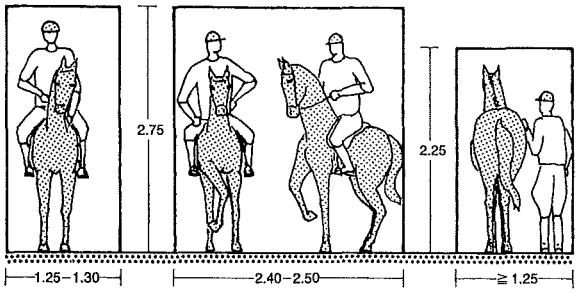
Saddle rooms, as far as possible, should be long and rectangular, with a large wall space and a width of 4.0–4.5 m. Saddles can be hung in three rows, staggered above each other → ❽. Saddle rooms and grooming rooms should have heating and be well ventilated.

In riding arenas the minimum headroom for show-jumping and horseback acrobatics is 4.00 m → ❺ – ❻. No universal rule can be applied to the space allocated to spectators. In general, though, spectators should not look down too steeply on the horses. An effective solution can be to use a spectators' gallery → ⓫, with the first row for seating and the second for standing. Behind this is room for two rows of circulating people. This arrangement will create 200 seated and standing places in a 20 × 40 m arena. The size of the main entrance has to be large enough to allow access for medium-sized lorries (3.00 m wide, 3.80 high). Side entrances should be 1.20 m or more wide and min. 2.80 m high. Doors have to open outwards.

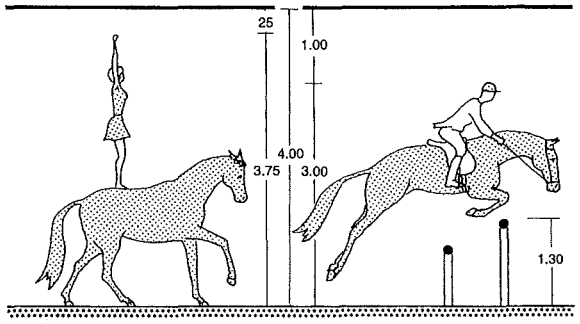
The ring fence as enclosure of a riding ring has many purposes → ⓬. It simplifies dressage riding of horses and saves the riders from injury. Angle of the slope to the vertical ≧20°. Glass windows < 2 m above the floor of the riding arena should be protected by a fine mesh grille. An exercise area of approx. 1000 m² is sufficient for 10 horses, mostly in pairs daily and weekly.



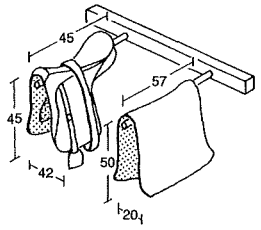
❶ Dimensions of horse and rider



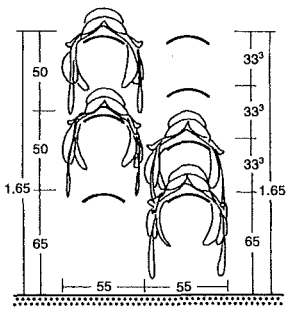
❷ Stable entrance, mounted ❸ Door/stable passage ❹ Horse and rider, dismounted



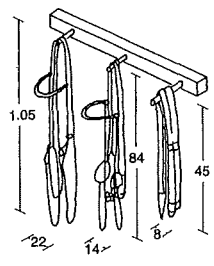
❺ Space for stunt riding ❻ Space for show-jumping



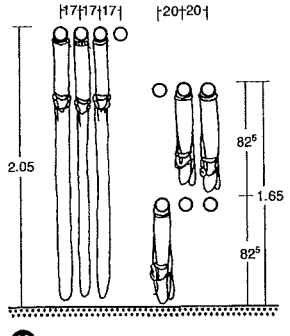
❼ Saddle with blanket



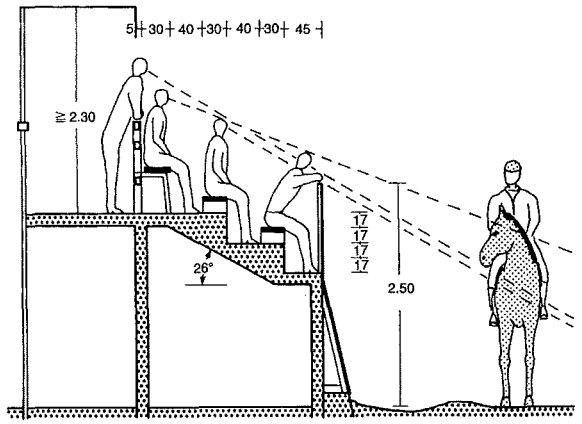
❽ Saddle rack on wall



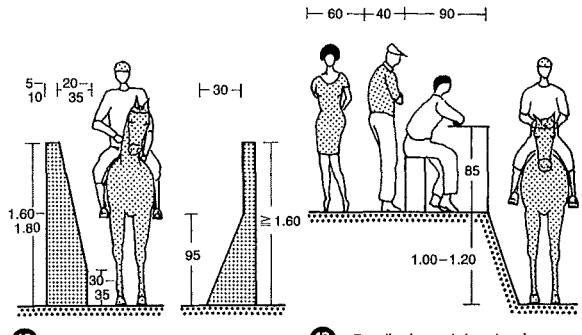
❾ Tack rack



❿ Bridle rack



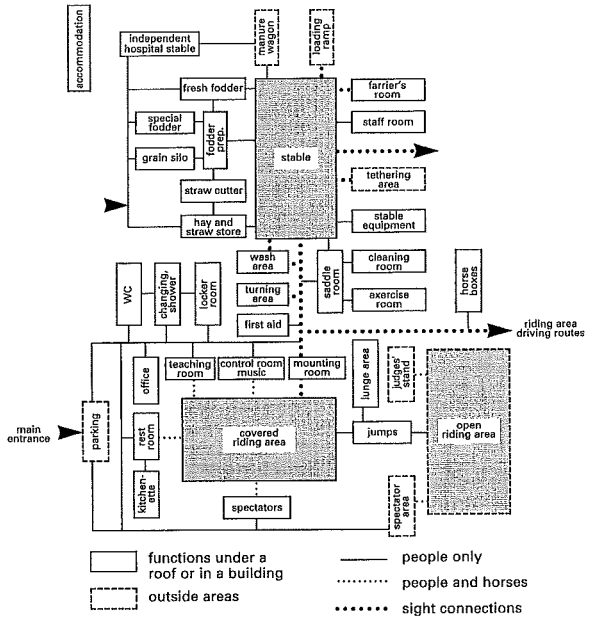
⓫ Spectator stand with access passage



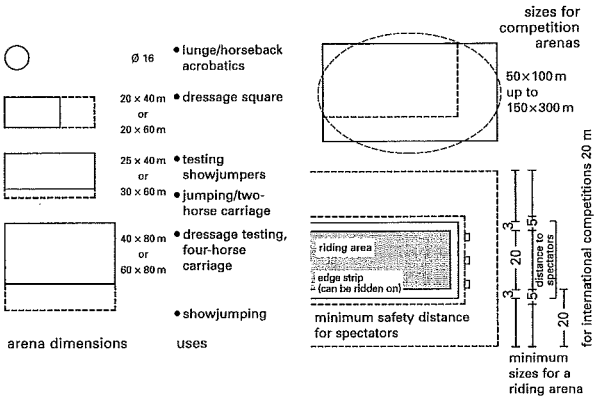
⓬ Ring fence profile ⓭ Practical spectator stand

Most of the operational functions of the various types of riding facilities are basically the same, apart from variations due to special operational features or local conditions. Building specifications vary primarily according to the size of the business or stable occupation number, which is decisive for the design of the individual elements and determines whether various functions can be combined → ❶. Generally, the core of the organisation is the buildings needed for the accommodation, care and feeding of the horses, always designed as a self-contained structure. A covered riding area is essential to enable activity to continue in all weathers. Flats for stable boys, grooms and instructors should be designed together with the facilities.

The long axis of the show-jumping arena should be aligned north–south out of consideration for the horse and rider → ❸ because most of the jumps are approached towards the main axis of the riding arena. Tournament arenas, which are aligned north–south, should have the stand for the judges and single-sided spectator stands on the west side, because major events take place in the afternoon. The minimum area of the riding space is 20 × 40 m net (pure riding area) → ❷. 20 × 60 m riding areas are required for dressage from class M and eventing. The riding space needs additional spaces at the sides (≧3.0 m) and at the entrance (≧5.0 m), so the arena has a gross area of 26 × 48 m → ❷. For competitions, the minimum distance of the spectators from hooves is 5 m, for indoor trials 20 m.



❶ Scheme of the indoor spatial relationships of a riding facility



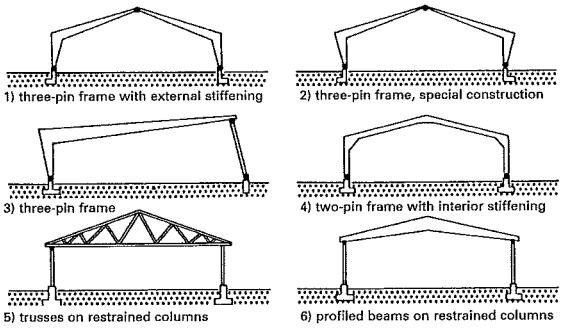
❷ Functional dimensions of open-air riding areas

format of riding halls	arena dimensions	uses
○	≧ 14.0 m	lunge/horseback acrobatics: alternative to a hall in the smallest clubs and private stables; used to relieve the main arena in larger establishments
▭	12.5 × 25.0 m	smallest arena: for private stables only and as an emergency solution for clubs; suitable as a second arena for larger establishments
▭	15.0 × 30.0 m	private stables and smaller club stables; second arena for larger establishments
▭	20.0 × 40/45 m	normal size for every type of establishment; dressage exams possible
▭	20.0 × 60.0 m	for larger establishments and institutions which specialise in dressage
▭	25.0 × 66.0 m	for large schools providing jumping and dressage training, and boarding establishments; hall dressage exams possible

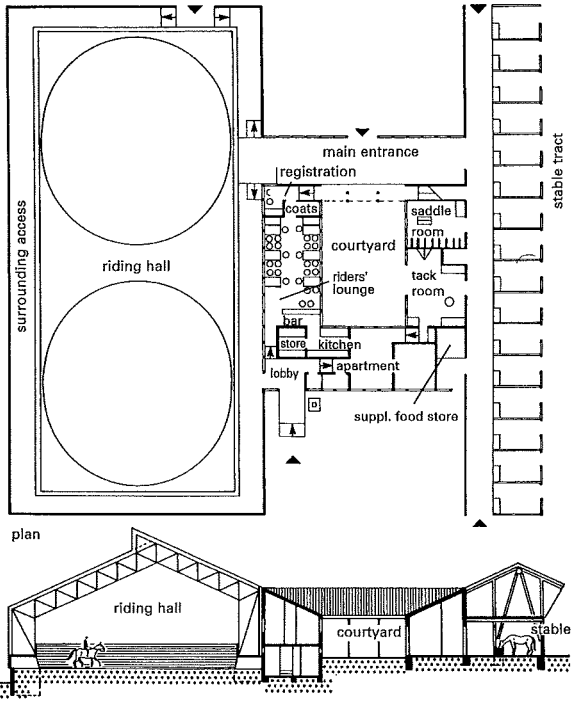
❸ Clear dimensions of riding halls

Stored substance		100 kg needs m³ space	Daily requirement per horse (kg)	Stored quantity per horse		
				No. of months	kg	m³
oats (grain)		0.22	5	1	150	0.33
hay	long, stored compressed	1.00–1.18	8	12	2900	29–34
	wired bales	0.59				17
straw	long, stored compressed	1.43–2.00	approx. 20 (clean straw for box stalls)	3	1825	26–37
	strung bales	1.05–1.18				19–22
	wired bales	0.42–0.50				8–9
	chopped 100 mm long	2.22–3.33	approx. 15		1375	31–16

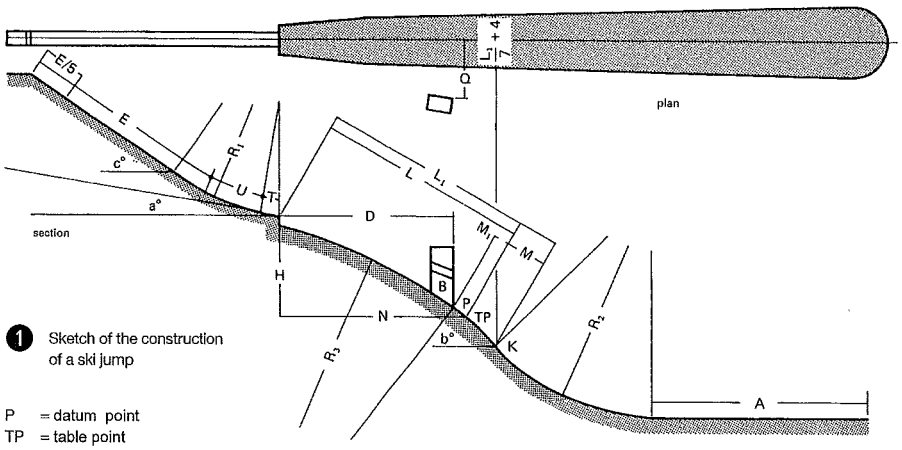
❹ Storage space for horse feedstuffs



❺ Riding hall cross-sections



❻ Riding facility in Gerolstein/Eifel — Arch.: Schnitzer



1 Sketch of the construction of a ski jump

P = datum point
TP = table point
K = critical point (end of section where slope is parallel to the flight path)
B = end of the landing track curve
M = slow-down section (distance from P to K)
M_1 = distance from P to B
L = distance from edge of slope to P
L_1 = distance from edge of slope to K
H = vertical projection of L
N = horizontal projection of L
H:N = ratio of vertical to horizontal
a = slope of launch platform
b = slope of landing track from normal point (P) to critical point (K)
c = slope of starting ramp
R_1 = radius of curve from starting ramp to launch platform
R_2 = radius of curve from landing track to run-out
R_3 = radius of curve from launch platform to landing track
T = length of launch platform
U = part of starting ramp, in which speed no longer increases
E = part of starting ramp, in which speed increases
F = total length of starting ramp (F = U + E + T)
A = length of run-out
V_o = speed at launch platform in m/s
D = horizontal distance from launch platform to lower edge of judge's tower
Q = distance from the landing track axis to front edge of judge's tower

2 These symbols should be used

medium and large ski jumps											
E			L								
c	c	c	9–12°						8–10°		←a
30°	35°	40°	U	T	V_o	H:N = 0.56	0.54	0.52	0.50	0.48	b ↓
62	52	44	8.8	4.6	21				53.0	51.0	35–37°
71	58	49	9.7	4.8	22	65.3	63.0	60.8	58.5	56.2	
80	65	54	10.6	5.1	23	71.5	69.0	66.5	64.0	61.5	36–38°
89	72	60	11.4	5.3	24	77.7	75.0	72.2	69.5	66.7	
99	80	67	12.5	5.5	25	84.0	81.0	78.0	75.0	72.0	37–39°
111	90	74	14.0	5.7	26	90.2	87.0	83.7	80.5	77.2	
124	100	81	15.0	5.9	27	96.3	93.0	89.5	86.0	82.5	38–40°
137	110	88	16.0	6.2	28				91.5	87.7	

3 Dimensions of medium and large ski jumps

small ski jumps													
E						L							
c	c	c				8–10°		7–9°		6–8°		← a	
30°	35°	40°	U	T	V_o	H:N = 0.50	0.48	0.46	0.44	0.42	0.40	0.38	b↓
26	23	21	4.5	3.3	15	20.0	19.5	19.0	18.5	18.0	17.5	17.0	30–34°
32	28	25	5.1	3.5	16	25.5	24.8	24.0	23.3	22.5	21.8	21.0	30–35°
39	32	28	5.8	3.7	17	31.0	30.0	29.0	28.0	27.0	26.0	25.0	33–36°
46	37	32	6.5	4.0	18	36.5	35.3	34.0	32.8	31.5	30.3	29.0	33–36°
52	43	37	7.2	4.2	19	42.0	40.5	39.0	37.5	36.0	34.5	33.0	34–37°
59	49	42	8.0	4.4	20	47.5	45.8	44.0	42.3	40.5	38.8	37.0	34–37°

4 Dimensions of small ski jumps

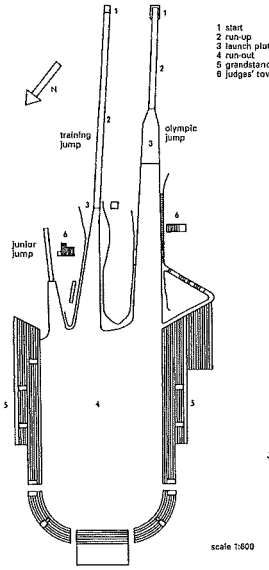
Example: according to the terrain, the following details were given for L1 and H:N, for example H:N = 0.54; c = 35°; L = 87 m.
In the table, you can find: L = 87 and in the left column V_o = 26; at the same level under c = 35°, E = 90 m, U =14 and T = 5.7; F = E + U + T = 90 + 14 + 5.7 = 109.7 m.
A ski jump which has dimensions different from the above can be approved by the FIS. In such a case, the designer of the ski jump must provide a detailed justification in writing.

The distance of the parapet of the lowest judge's cabin from the horizontal 'd' through the tip of the ski jump = D × tan 16° – tan 20°. The cabins should be arranged as steps in the sloping line passing through the ski jump table edge to the end of the point 'd'. The upper edge of the floor of the individual cabins is 1–1.20 m below the parapet. The slope of the tower to the track axis should be 7–10°, so that the judge can observe the entire flight and landing. At the top of the starting ramp, as many starting places as possible should be uniformly distributed along the length E/5, whose vertical spacing should be about 1 m. Lowest starting place = E – E/S.
Minimum width of the landing piste at K = Li/7 + 4 m.

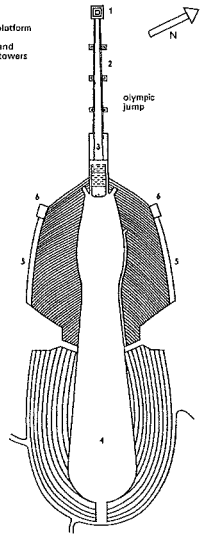
Notes:
All slopes are to be given in old divisions (360°). If the transfers are parabolic, then R1 and R2 are the smallest curves of the parabolas. If the starting ramp is natural, the parts actually used should be marked every 2 m in order to simplify the exact determination of the starting place. The slope of the ski jump table and also a number of points on the curve between starting ramp and the tip of the ski jump table should be determined on both sides with fixed profiles, so that even non-experts can produce the exact and correct profile during the construction of the jump. It is recommended that profile markers should be placed at both sides alongside the landing profile and into the run-out to enable the creation of the exact snow profile, particularly if there is a lot of snow. Ski jumps whose L is >50 m should not normally be built with a V_o <21 m/sec. Ski jumps with L >90 m are not approved by the FIS (International Ski Federation); exception: flying ski jumps.

The standard values for the most important parts of the ski jump:
H:N = 0.48–0.56
The datum point of a ski jump is to be determined:
P = L_1–M, where the standards are for M:
M = 0.5–0.8 V_o for ski jumps up to P = 70 m
M = 0.7–1.1 V_o for ski jumps up to P = 90 m
M = 0–0.2 V_o
R_1 = 0.12 V_o^2 – 0.12 V_{o2} + 8 m
R_2 = 0.14 V_o^2 – 0.14 V_o^2 + 20 m
R_3 = profile for the front structure is selected to best suit the flight profile
T = 0.22 V_o
U = 0.02 V_o^2
A = 4–5 V_o with horizontal run-out
D = 0.5–0.7 × L_1 to lower edge of the tower
Q = 0.25–0.50 × L_1

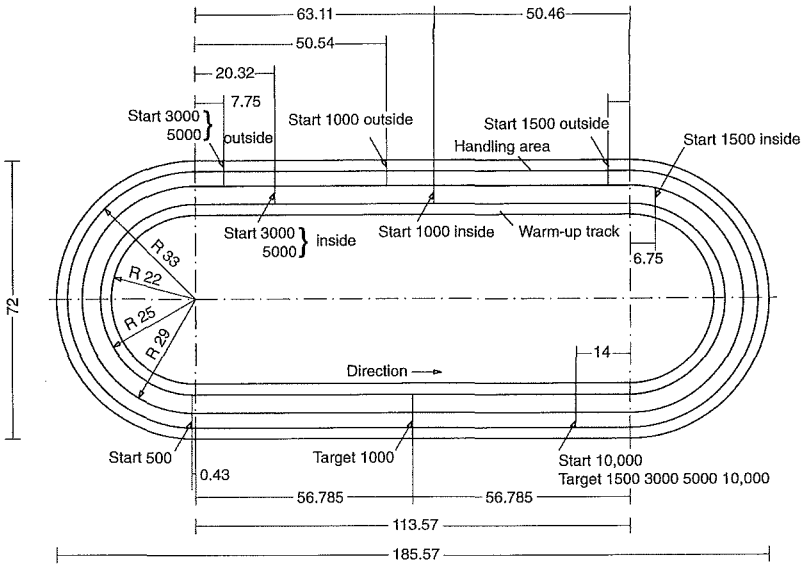
5 The data point of a ski jump is to be determined



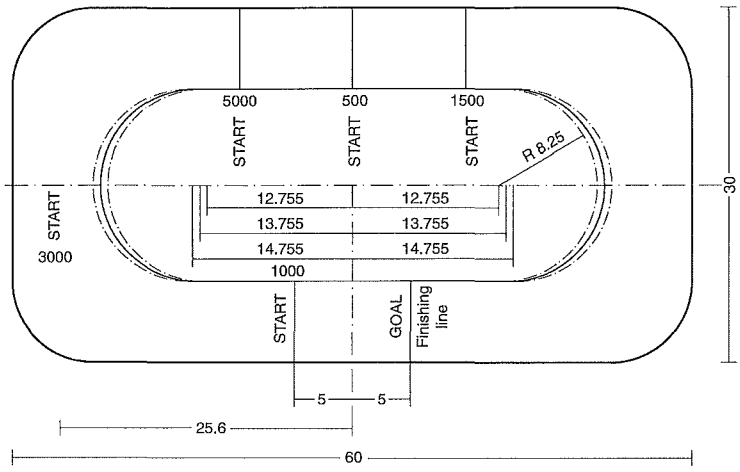
6 Garmisch-Partenkirchen



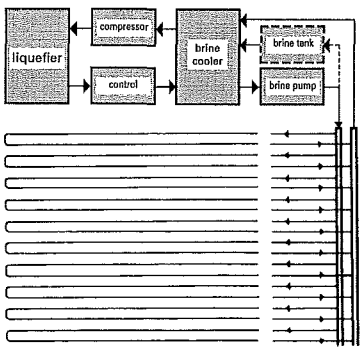
7 Holmenkollen



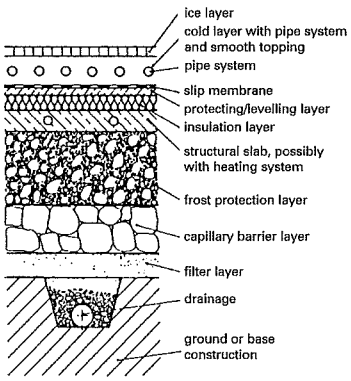
1 Standard ice racing rink with marking



2 Plan for short track



3 Artificial ice rink: scheme for a cooling plant (brine operation)



4 Laid pipes → 3

Ice rinks are for skating, ice hockey and curling, which may of course also take place on naturally frozen lakes and rivers, also on frozen open-air swimming pools (the edge must be strong enough to resist ice pressure).

Sprayed ice rinks can be created on tennis courts, roller skating rinks and other large flat areas (surrounding wall about 10–15 cm). Water is sprayed 2 cm thick; drainage will be needed for water run-off.

Artificial ice rinks with cooling pipe system, 2.5 cm under screed layer. Pump system with deep-frozen salt solution or chambers with cold air (mostly ammonia compression process) → 3 – 4.

Standard ice racing rink. Length ≧300 m; 333⅓ m; normal 400 m. Measured 50 cm from the inner edge of the track. Radii of the inner curves ≧25 m crossings ≧70 m. It should be a double track → 1.

2 × central axis = 2 × 111.94 = 223.89 m
inner curve = 25.2 × 3.1416 = 80.11 m
outer curve = 30.5 × 3.1416 = 95.82 m

$$\frac{\text{crossing}}{\sqrt{\text{crossing length}^2 \times \text{track width}^2}}$$

from 70 m = 0.18 m
total length 400 m

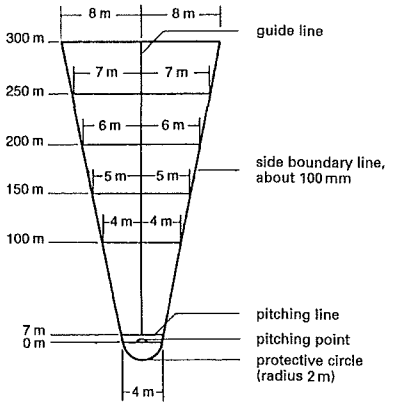
Standard ice racing track
Width of a circular track: 4 m; width of the inside warming-up track: 3 m (for better training, 4 m is recommended).

Bob tracks with steeply banked curves of ice blocks. Spectator places should ideally be inside curves, otherwise with protecting walls of snow or straw bales in front of them.

Toboggan tracks lie on N-NW-NE slopes, ideally in a hollow. Length 1500–2500 m; slope 15–25%; width ≧2 m.

Flat run-out or uphill section, banking of curves and protection of obstacles with straw bales or snow walls. Climbing up not on the track but next to it.

Long curling rinks → 5

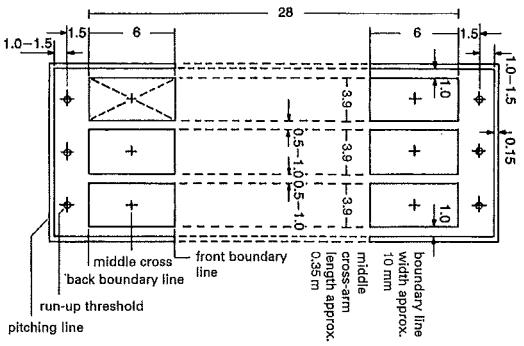


5 Long curling rink → p. 345

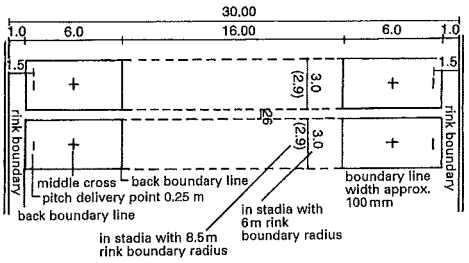
Sport and leisure

SPORTS FACILITIES
Playing fields
Athletics
Tennis
Miniature golf
Golf courses
Water sport, marinas
Water sport, rowing and canoeing
Equestrian sport
Ski jumping
Ice rinks
Roller skating rinks
Speed roller skating, skateboarding
Cyclo-cross, BMX
Shooting ranges

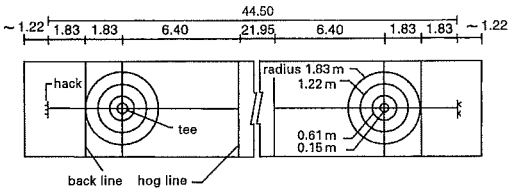
DIN 18036



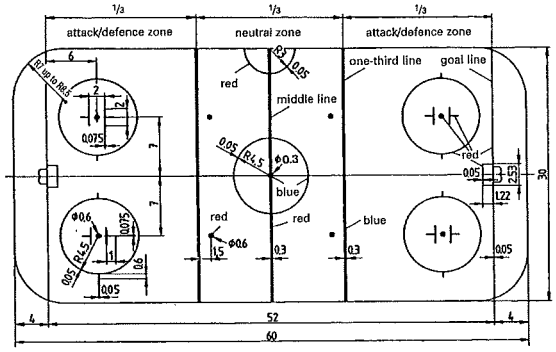
❶ Curling rink



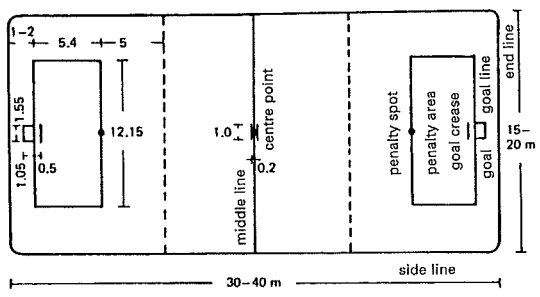
❷ Ice stock sport in an artificial ice rink



❸ Scottish curling sheet



❹ Standard rink with markings for ice hockey



❺ Roller hockey rink

Ice stock or Bavarian curling → ❶ playing area length 28 m; width 3.9 m (30 × 3 m is also possible). Between playing areas, bands 1 m; at the ends ≧60 cm. Start and target areas are enclosed on three sides by wooden barriers, which can be stepped over.

Curling → ❸: playing area (sheet) length 44.5 m; target circle (house) ≧3.65 m. To the centre point of the target circle 34.74 m, shortened on bad ice to 29.26 m. Curling stone: weight ≧19.985 kg. Circumference ≧91.4 cm, height ≧⅛ of circumference.

Long curling rinks → p. 344 → ❺.

Ice hockey: playing field 30 × 61 m. Goal 1.83 m wide, 1.22 m high, play continues behind it. Playing field requires 1.15–1.22 m high perimeter barrier (wood or plastic) → ❹.

Figure skating: ice area rectangular ≧56 × 26 m ≧30 × 60 m. Combination of roller skating rink in summer (March to November) and ice rink in winter (December to February). Cold pipe system 2.5–5 cm under the surface of the rink (not possible with terrazzo)

ROLLER SKATING RINKS

1. Sport rinks	
roller hockey	15 × 30 to 20 × 40 m
roller figure skating	25 × 50 m
2. Recreational rinks	10 × 10 to 20 × 20 m

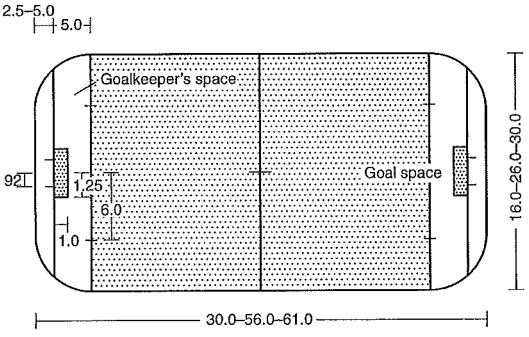
Crash board 25 cm high, 3 cm over rink, 80 cm parapet on all sides, 2 m wire mesh fence at the ends (to catch the ball), perimeter round playing area 1.2 m; 5–10 cm deeper, joints ≦5–6 mm, gradient ≦0.2‰. Surface water in gutters or trenches, frost protection layer ≧20 cm → ❺.

Construction types

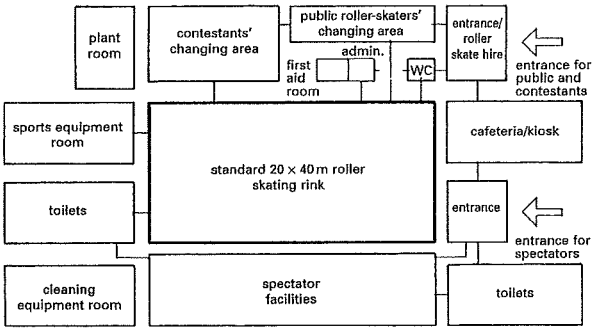
1. Fibre cement boards, 15 mm; laid on squared timbers or on a sand bed.
2. Concrete tracks, 10–15 cm according to sub-base properties, as few joints as possible, possibly cut dummy joints 2–3 mm wide, expansion joints every 25–30 m, width ≧15 mm.
3. Hard concrete screed, ≧8 mm on fresh base concrete (if possible, with 2 cm cement mortar as stress compensation between screed and base concrete).
4. Cement screed with additives 1–10 mm.
5. Terrazzo, ground, ≧15 mm, brass, aluminium or plastic joint strips, only indoor.
6. Poured asphalt, on solid base layer,-, as usual.

Skater hockey → ❻

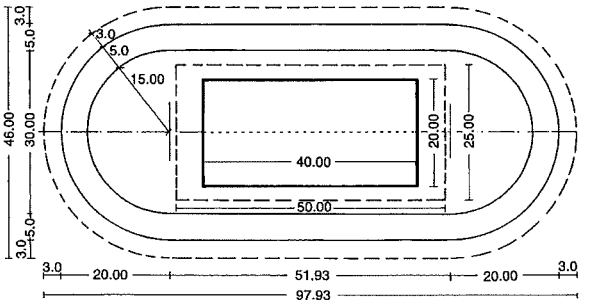
The playing surface consists of wood, tiles, parquet or other flat and smooth materials suitable for roller skating. The rink is surrounded by a ring barrier min. 0.20 m and max 1.22 m high. Hall walls are also allowed.



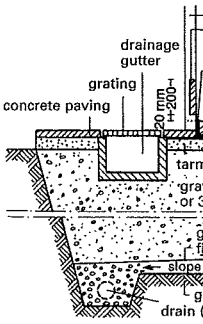
❻ Skater hockey



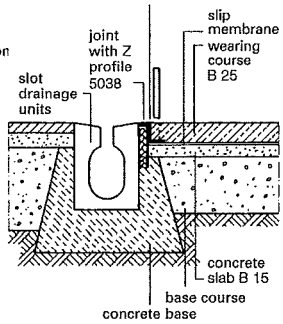
❶ Functional diagram of a speed roller skating rink



❷ Dimensions of a 200 m speed roller skating track with inner standard rink 20 × 40 m



❸ Example of paving: with drainage on cohesive soil



❹ Edge detail: floating slab without fixed point or step down to perimeter

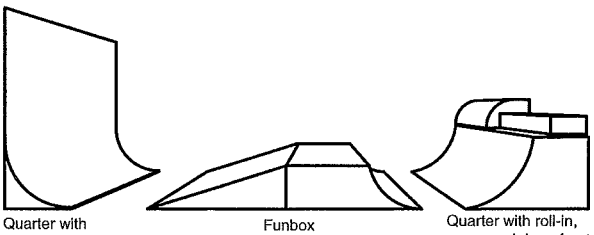
Space required: standard area 20 × 40 m → ❷
Rooms for athletes:
2 (4) communal changing rooms, each with 8 m bench and clothes hangers (roller hockey, 4 communal changing rooms). For roller hockey, if required additional clothes hooks every 3 m².
2 shower rooms with 4 showers, drying zone, 2 washbasins, 2 hairdryers and separate toilet in anteroom. 4 drying rooms (only roller hockey) per 6 m². 1 umpires' and trainers' room, approx. 9 m².
Facilities for public speed skating: entrance area with ticket machine and turnstile or staffed cash desk, approx. 40 m². Changing rooms for public skating, also serve for putting on skates. Use all-year-round. 30 single, 60 double lockers and bench length 20 m.
1 ladies' toilet with 2 WCs, separate anteroom and washbasins. 1 gents' toilet with 2 WCs, 3 urinals, separate anteroom and washbasin, 1 sanitary room 9 m², 1 skate rental room 12 m² (in connection with cash desk).
1 supervisor and control room (also control room for lighting and loudspeaker system) 8 m². Changing, shower, washbasins, toilets and cloakroom for 1–2 people, 1 workshop 4 m², 1 sporting equipment room (large items) 15 m², 1 sporting equipment room (small items) 6 m², cleaners' room 12 m², heating 10 m², electricity room 4 m², supply room 3 m².

Possible uses	Required skating area (m)	Remarks
public roller skating, roller figure skating, roller dancing and roller hockey	20 × 40 m	**standard area** min. area for roller hockey 17 × 34 m
public roller skating, roller figure skating, dancing and hockey	20 × 50 m	in particular cases
public roller skating, roller figure skating, dancing and hockey, inline speed skating and ice rink	30 × 60 m	in general only if combined with ice rink; 110 m short track for speed skating is possible on an area of 30 × 60 m
inline speed skating track	200 m 333⅓ m 400 m	**standard track** only in combination with cycle track and ice speed skating rink
track width	5 m	

❺ Possible uses and dimensions of sports areas

SKATEBOARDING

Skateboarding is related to inline skating and roller facilities are also suitable for skateboarding. Space required for a facility min. 200 m².
Suitable locations: 1. Existing road-like surfaces in schoolyards, playgrounds, ice rinks, closed roads, separated areas of car parks, houses and back yards. 2. Suitable paving newly laid in sports centres, public parks and green areas.



Quarter with wall ride
Height + wall: 2 m
Width: 3 m
Radius: 2 m

Funbox
Height: 1.35 m
Width: 2.5 m
Radius/jump: 2.5 m
Table length: 2.5 m
Landing: 4.2 m

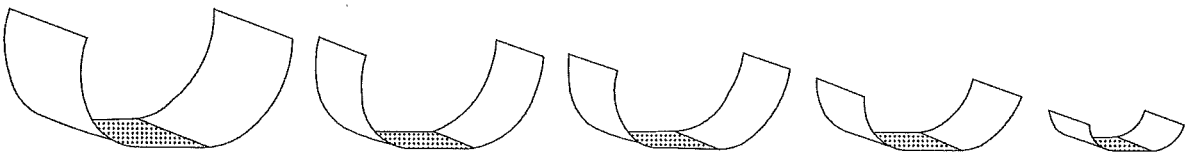
Quarter with roll-in, rear or sub box, front
Quarter
Height: 2 m
Width: 4 m
Radius: 2.5 m
Table length: 1.5 m
Roll-in (top part at back)
Height: 1 m
Width: 1.25 m
Radius: 2 m
Sub-box (top part at front)
Height: 1 m
Width: 2 m
Depth: 90 cm

It should be noted for layouts for flybox jumping: The run-up must always be higher than the jumping point. Normally, twice the jump-off height.

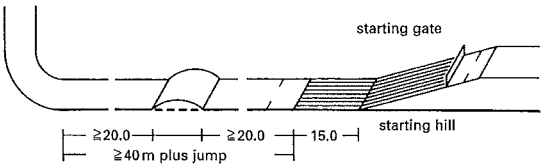
❻ Flybox for jumping with skateboard, inline skates and BMX bikes

Type	Height (m)	Width (m)	Radius (m)	Centre part (m)	Verticals (m)
skateboard mini-ramp	1	5	1.5	2	none
BMX mini-ramp	2	6	2.5	3	none
fun pipe	3	6	2.8	3	0.3
half-pipe – standard	3.5	6	3	3	0.5
half-pipe – king-size	4.1	10	3.5	3.5	0.6

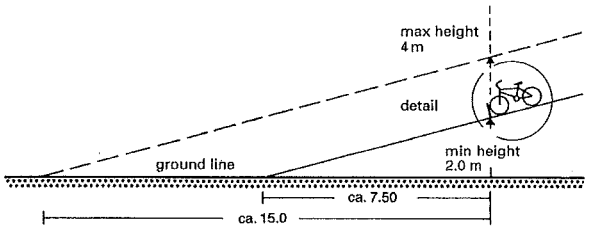
❼ Dimensions of half-pipes



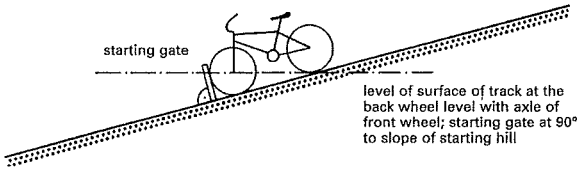
❽ King-size half-pipe
❾ Standard half-pipe
❿ Fun pipe
⓫ BMX mini-ramp
⓬ Skateboard mini-ramp



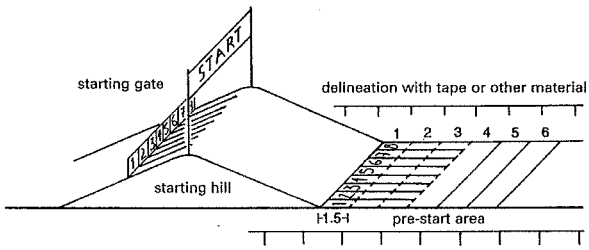
1 Starting hill



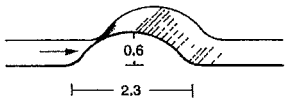
2 Heights of the starting hill



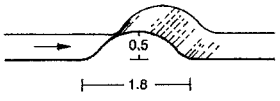
3 Starting hill detail → 2



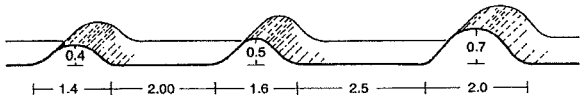
4 Starting ramp with pre-start area



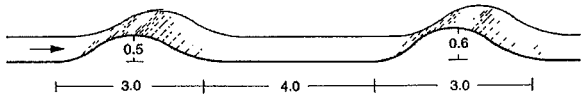
5 Speed jump



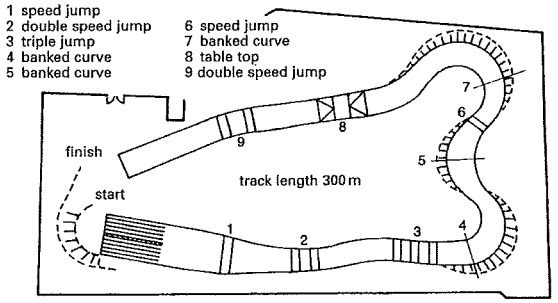
6 Speed jump



7 Triple jump (or triple combination)



8 Double speed jump



13 BMX track at the WM '87 in Bordeaux

Minimum plot size for BMX sport facilities 50 × 60 m. Maximum dimensions for a generous track with sufficient spectator places 100 × 200 m. Observe safety spacing of tracks in opposite directions. Four types of BMX track are possible according to local conditions.

C track, B track, A track/national, A track/international.

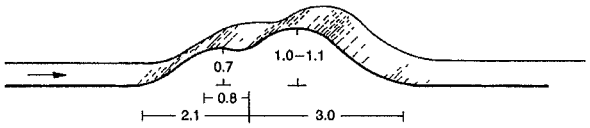
C track min. length 200 m. Starting hill width = 5 m = 4 starting places,

B track 250 m. Starting hill width = 7 m = 6 starting places, min. lap time 30 s.

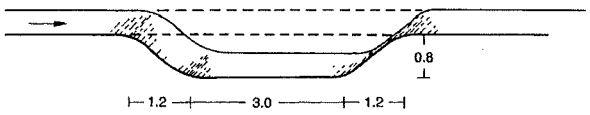
A track/national min. length 270–320 m. Starting hill width = 9 m = 8 starting places, min. lap time 35 s.

A track/international min. length 300 m Starting hill width = 9 m = 8 starting places, min. lap time 35 s.

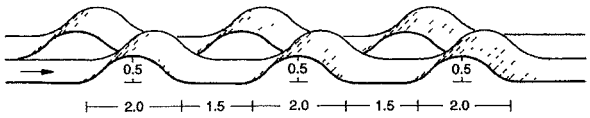
Paved surface on the starting straight. Lap time must be achievable by an average 15-year-old rider. Trackside markings are not of solid materials (stone, concrete, timber or similar). Safety barriers of car tyres or straw bales are sufficient. Fixed barriers must have a min. distance of 1 m. Closure to spectator space must be marked with warning tape. No spectators allowed inside the track. Max. speed on downhill sections 40 km/h. Curves and obstacles can be placed as desired along the course.



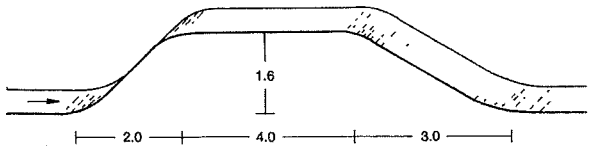
9 Step jump



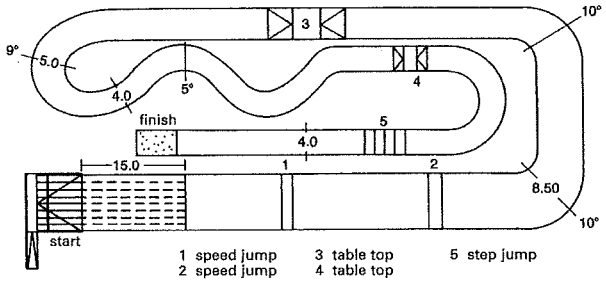
10 Canon jump



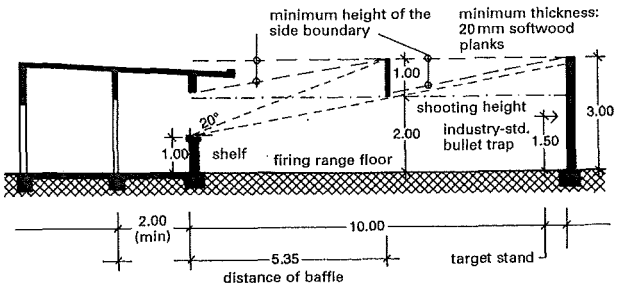
11 Mogul jump (moguls)



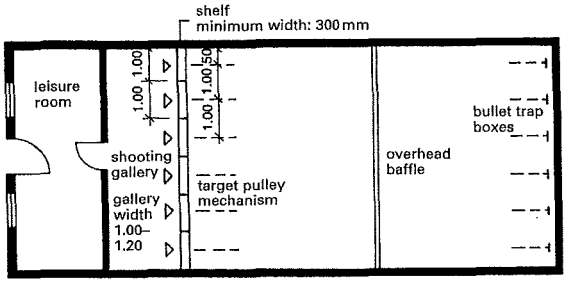
12 Table top



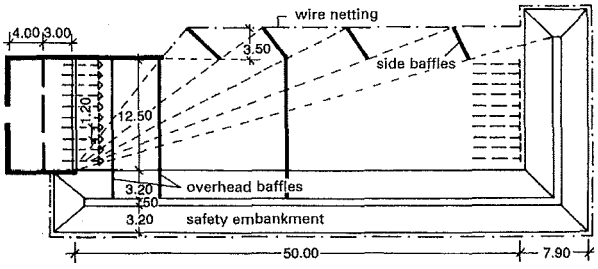
14 BMX track at the IFMA '84 in Cologne



1 Section → 2



2 Shooting range for air pressure and CO_2 guns, covered shooting gallery, open-air range



3 Small-calibre range for target-pulling

Location: if possible in a gully within a wooded area, with surrounding hillside to catch bullets naturally, away from public roads and buildings. Shooting ranges are also possible in buildings, e.g. in combination with public multi-purpose sports halls. Common categories are air gun range, pistol and small calibre range → 1 – 5 → p. 349.

The safety requirements for Germany are laid down in the 'Guidelines for the construction and acceptance for shooting ranges for sporting and hunting shooting' from the German Shooting Association. Apart from the normal permission for the building of a shooting range, a report is also required from an accredited shooting range expert. The right of 'neighbours' to object on the grounds of noise nuisance is mostly upheld. Safety constructions like overhead baffles, side protection (walls or earth banks) and the closing off of the range must be built of approved construction materials or are tested by the expert.

In the UK, rifle and pistol (but not air gun) ranges require the approval and safety certificate of the Ministry of Defence. Early approval is also needed from the National Small-Bore Rifle Association (NSRA) or the National Rifle Association (NRA).

Shooting programme

Olympic competitions: x = for men, xx = for women and men, xxx = only for women.

Rifle shooting: air rifle 10 m xx; Zimmerstutzen rifle 15 m; small-calibre rifle 50 m x; KK standard rifle xxx; sport rifle 100 m; large-calibre rifle 300 m; GK standard rifle 300 m.

Pistol shooting: air pistol 10 m xx; Olympic quick-fire pistol 25 m x; sport pistol 25 m xxx; standard pistol 25 m, free pistol 50 m x.

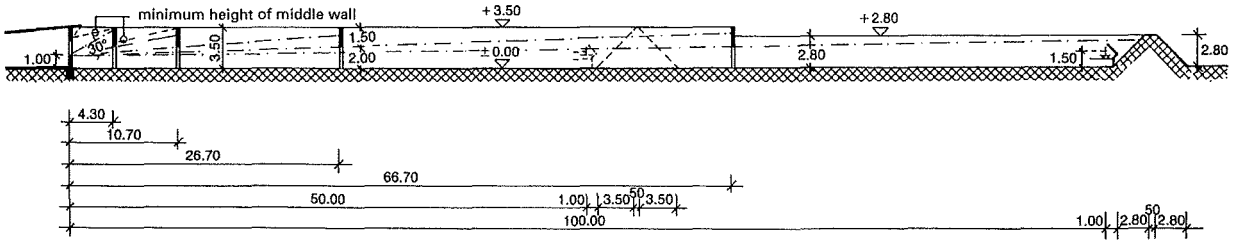
Clay pigeon shooting: trap shooting x; skeet shooting x.

Running target: moving boar, 10 m and 50 m x.

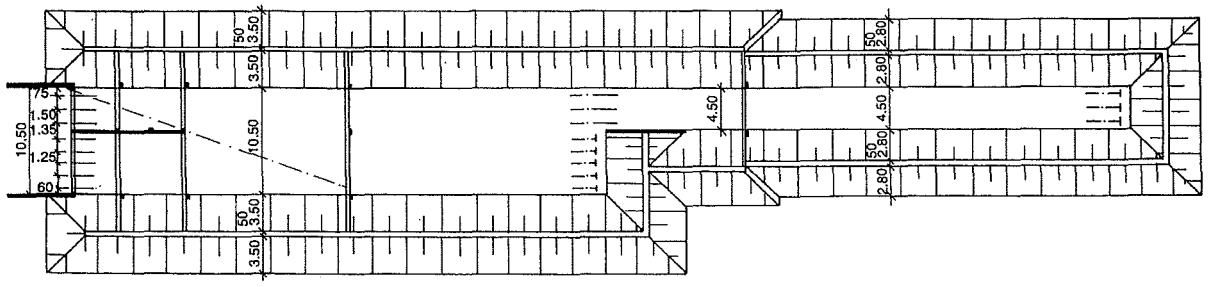
Archery: hall conditions, international conditions xx, field bow.

Crossbow: national conditions, international conditions 10 and 30 m.

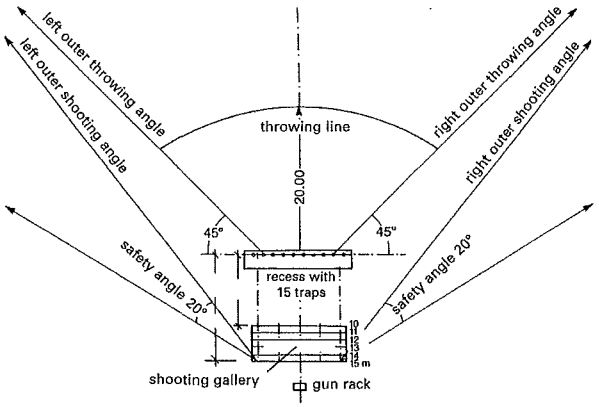
Muzzle loader shooting: national conditions.



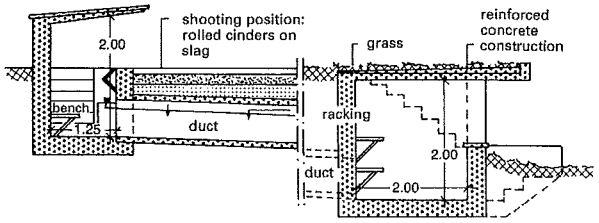
4 Cross-section → 5



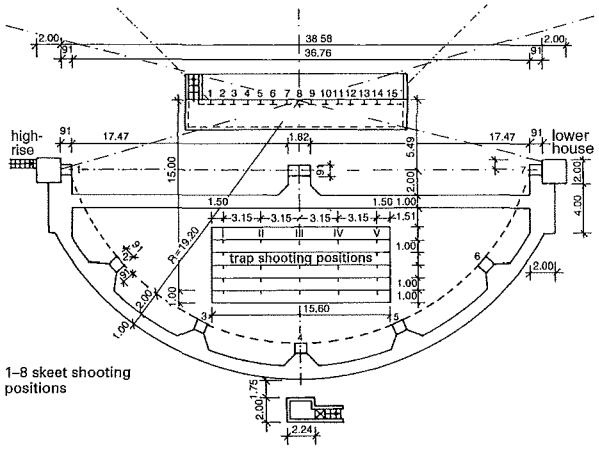
5 Combined 100 m range for all rifles and a 50 m small-calibre range → 4



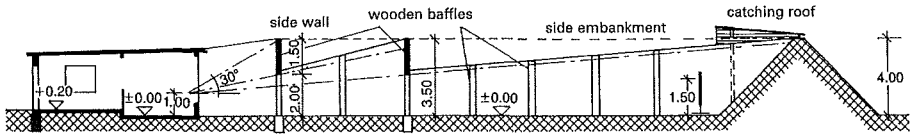
1 Clay pigeon shooting range



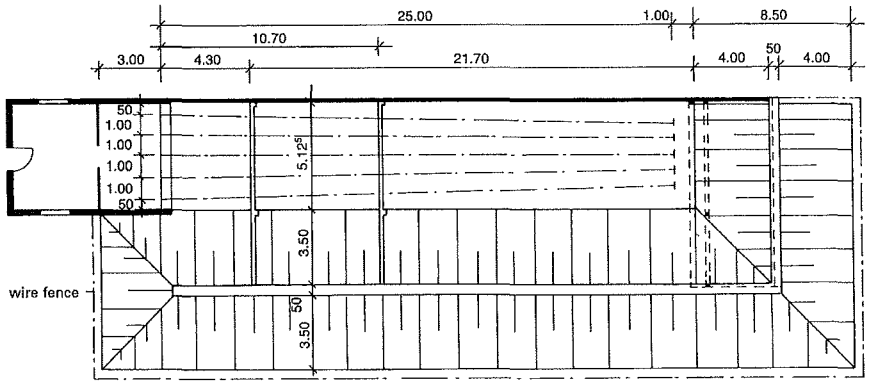
2 Longitudinal section through clay pigeon range



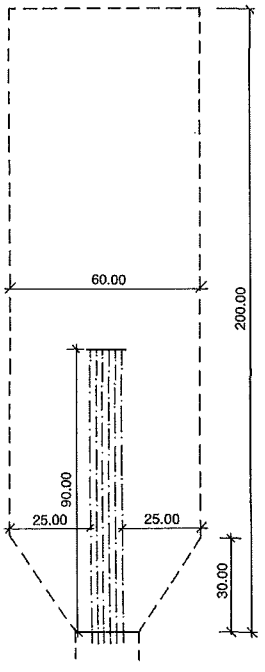
3 Combined trap and skeet shooting range



4 Section → 5



5 25 m range for handguns (pistols and revolvers of all calibres). Left, a continuous side wall and, right, continuous earth bank (wall or earth bank can be used either side).



6 Danger zone for archery range with six targets

Elevation safety

The total range of a shot is mainly determined by the ideal angle of elevation. According to experience, the vertical elevation needing to be safely restrained is 20° for air pressure and CO_2 guns and Zimmerstutzen rifles, and 30° for rifle ranges and handguns.

For high crossbow and archery ranges, the regulations differ. Endangered areas are to be protected by dedicated safety structures. A shooting range must be constructed so that, according to experience, no danger to shooters taking part can arise internally nor externally to the surrounding neighbourhood. The requirements of the Federal Pollution Control Law must be complied with.

An assessment whether a specific site is suitable for the building of a shooting range is essential for the estimation of the cost of building. An accredited expert on shooting ranges can provide the architect with the necessary specialist information, and should always be consulted. Particular points to note are:

Distance from existing or planned built-up areas and inhabited houses, intended shooting direction (north or north-east), soil conditions and features of terrain, utility supplies, waste disposal, road connection, routeing of roads (also planned), car parking, holiday and leisure areas. Can or must there be deviations from the guidelines? Any required protection measures should be included in the design from the start. Ranges can be built in separate construction sections.

The procedures for approval and permission are determined by state regulations. The layout and extent of a shooting range should include the consideration of additions and extensions, which could become necessary in the future and can be built at reasonable cost. The design of open-air ranges should include noise protection measures.

SPORTS HALLS

Dimensions

The design basics are: multi-functional hall, sports hall and multi-purpose hall. The design has to include consideration of the competition rules of the specialist sport associations and also the best-possible integration of the individual sports → ❶.

The required site size depends on the playing area required and the administrative offices. It can normally be estimated as follows if the detailed room schedule is not yet available: required sports area × 2 + necessary open areas to the site boundary + necessary parking space for vehicles.

Dimensions of halls → ❶. Halls capable of being subdivided are preferable, on grounds of flexibility, to a number of single halls.

Operational rooms for sporting events

Entrance hall, with cash desk, spectators' cloakroom and perhaps cleaning equipment room, based on → ❷ 0.1 m² per spectator. Space needed per seat for spectators and VIPs, press, radio and television (incl. immediate traffic area): 0.5 × 0.4–0.45 m; per press place 0.75 × 0.8–0.85 m; per reporting cabin 1.8 × 2.0 m; per camera platform: 2.0 × 2.0 m. 1 cloakroom place for every 3 spectators, 1 m of cloakroom service counter for every 30 cloakroom places. No. toilets per spectator: 0.01: 40% WCs, ladies; 20% WCs, gents; and 40% urinals. Per seat incl. anteroom 2.5 m², per urinal incl. anteroom 1.0 m². cash desk, cafeteria, police, fire service, administration, storeroom, press rooms as required.

Hall type	Dimensions (m)	Usable playing area (m²)	Hall sports[1]	No. training courts/fields	No. competition courts/fields[2]
Multi-functional halls					
single hall	15 × 27 × 5.5	405	badminton basketball volleyball	4 1 1	
triple hall	27 × 45 × 7[3][4] divisible into 3 sections (15 × 27)[5]	1215	badminton basketball indoor football indoor handball indoor hockey volleyball	12 3 3	5[6] 1 1 1 1 1
quadruple hall	27 × 60 × 7[3] divisible into 4 sections (15 × 27)[5]	1620	badminton basketball indoor football indoor handball indoor hockey volleyball	16 4 4	7[6] 2 1 1 1 1
possibly also double hall	22 × 44 × 7[3][4] divisible into 2 sections (22 × 28 + 22 × 16 or 22 × 26 + 22 × 18)[5]	968	badminton basketball indoor football indoor handball indoor hockey volleyball	6 3	5[6] 1 1 1 1 1
Sports halls					
single hall	22 × 44 × 7[3][4]	968	badminton basketball indoor football indoor handball indoor hockey volleyball	6 3	5 1 1 1 1 1
triple hall	44 × 66 × 8[3] divisible into 3 sections (22 × 44)[5]	2904	badminton basketball indoor football 20 × 40 30 × 60 indoor handball indoor hockey volleyball	24 9	15 4[6] 3 1 3 3 3
quadruple hall	44 × 88 × 9[3] divisible into 4 sections (22 × 44)[5]	3872	badminton basketball indoor football 20 × 40 40 × 80 indoor handball indoor hockey volleyball	32 5[6] 12	25[6] 4 4 1 4 4 4

[1] common indoor sports not incorporating national or regional customs
[2] dimensions according to guidelines of the international sport ruling bodies; can perhaps be reduced in national use
[3] height of hall can perhaps be reduced at the edges according to sporting functions
[4] if there are a number of halls on one site or in the planned area, height can be reduced to 5.5 m in part of the halls according to intended use
[5] less the proportional thickness of the relevant partition
[6] maximum number without consideration of the partition

❶ Dimensions of halls

Room	Dimensions (m)	Usable playing area (m²)
Conditioning/power training room	depends on equipment, min. height 3.5	35–200
Fitness room	depends on equipment, min. height 2.5	20–50
Gymnastics room	10 × 10 × 4 to 14 × 14 × 4	100–196

❸ Dimensions of rooms for additional sports

Hall type	Entrance hall (m²)	Changing rooms (min. 20 m²)[2]	Showers (min. 15 m²)[3]	Toilets			Teaching room[4] (min. 12 m²) without first aid function (min. 8 m²)	Equipment room		Cleaning equipment room min. 5 m²	Waiting room min. 10 m²
				per changing room	lobby min. no.			Multi-functional hall	Sports hall		
	m²	min. no.	no.	min. no.	F	M	min. no.	min. m² [5]	min.m² [5]	min. no.	no.
Single hall	15	2	1[6]	1	1	1	1	60[7]	20[8]	1	1[9]
Double hall	30	2	2	1	1	1	1	90[7]	—	1	1[9]
Triple hall	45	3[10]	3[10]	1	1	1	2	120[7]	60[8]	1	1
Quadruple hall	60	4[10]	4[10]	1	1	1	3	150[7]	80[8]>	1	1

[1] minimum room height generally 2.5 m
[2] space requirement per person is 0.7–1.0 m², based on allowances of 0.4 m bench length per person, 0.3 m sitting depth and min. 1.5 m between benches or between bench and wall (1.8 m recommended)
[3] 1 shower per 6 persons (but a minimum of 8 showers and 4 washbasins per facility), shower space including a minimum circulation area of 10 m² and circulation space at least 1.2.m wide
[4] training supervisors', umpire/referees' room, perhaps including first aid post (min. 8 m² for separate first aid room), with changing cubicle and shower; can also be used as an administration room if correctly positioned, designed and of sufficient size
[5] because the range of apparatus provided varies according to location, it is likely that these minimum dimensions will have to be exceeded; no hall section in a multi-functional hall should have less than a 6 m length apparatus room
[6] divided into 2 sections, each with half of the apparatus
[7] room depth normally 4.5.m, max. 6.0.m
[8] room depth normally 3 m, max. 5.5 m
[9] according to need
[10] alternatively, 2 bigger rooms with proportionally more shower and washing facilities

❷ Operational rooms for sports halls

SPORTS HALLS

Dimensions

Type of sport	Usable playing area (net)				Additional unobstructed zone at the:		Unobstructed playing area with standard dimensions (gross)		Clear hall height[1]
	Permissible dimensions:		Standard dimensions:						
	length (m)	width (m)	length (m)	width (m)	sides (m)	ends (m)	length (m)	width (m)	(m)
Badminton	13.4	6.1	13.4	6.1	1.5	2.0	17.4	9.1	9[2]
Basketball	24–28	13–15	28	15	1[3]	1[3]	30	17	7
Boxing	4.9–6.1	4.9–6.1	6.1	6.1	0.5	0.5	7.1	7.1	4
Fistball	40	20	40	20	0.5	2	44	21	(7)
Football	30–50	15–25	40	20	0.5	2	44	21	(5.5)
Weight lifting	4	4	4	4	3	3	10	10	4
Netball	40	20	40	20	1[4]	2	44	22	7[5]
Hockey	36–44	18–22	40	20	0.5	2	44	21	(5.5)
Judo	9–10	9–10	10	10	2	2	14	14	(4)
Netball	28	15	28	15	1	1	30	17	(5.5)
Sports acrobatics	12	12	12	12	1	1	14	14	(5.5)
Gymnastics	52	27	52	27	—	—	52	27	8
Cycle football/ polo/gymnastics	12–14	9–11	14	11	1	2	18	13	(4)
Rhythmic gymnastics	13[6]	13[6]	13[6]	13[6]	1	1	15	15	8[2]
Wrestling	9–12	9–12	12	12	2	2	14	14	(4)
Roller hockey	34–40	17–20	40	20	—	—	40	20	(4)
Roller acrobatics/ dancing	40	20	40	20	—	—	40	20	(4)
Sports dancing	15–16	12–14	16	14	—	—	16	14	(4)
Tennis	23.77	10.97	23.77	10.97	3.65	6.4	36.57	18.27	(7)
Table tennis	2.74	1.525	2.74	1.525	5.63	2.74	14	7	4
Trampolining	4.57	2.74	4.57	2.74	4	4	12.57	10.74	7
Volleyball	18	9	18	9	5	8	34	19	12.5[2]

[1] nos in brackets: recommended; [2] for national events, 7 m is sufficient; [3] for spectator stands bordering the playing area, ideally 2 m; [4] additional space requirement for timers' table and reserves' bench (poss. in sports equipment room); [5] in a 3.3 m wide zone around the playing area (net), a uniform reduction to 5.5 m is permissible; [6] for national competitions 12 m.

❶ Playing area dimensions for competitive sports use

Apparatus	Unobstructed total sport area[1] length × width × height (m)	Safety distance[2] (m)			
		Sides	Forwards	Backwards	To each other
Floor gymnastics	14 × 14 × 4.5	—	—	—	—
Pommel horse	4 × 4 × 4.5	—	—	—	—
Vaulting horse	36[3] × 2 × 5.5	—	—	—	—
Suspended rings[4]	8 × 6 × 5.5	—	—	—	—
Parallel bars	6 × 9.5 × 4.5	4.5[5][6]	4[5]	3[5]	4.5
Horizontal bar	12 × 6 × 7.5[7]	1.5	6	6	—
Assymmetric bars	12 × 6 × 5.5	1.5	6	6	—
Beam	12 × 6 × 4.5	—	—	—	—
Swinging rings[4]	18 × 4 × 5.5	1.5[5] (2) A	10.5[5] (7.5) A	7.5[5]	1.5[5]
Climbing rpe	—	1.5	4.5 (4) A	4.5 (4) A	1.5 (0.8) A
Header hanging ball	—	4.5[5]	4.5[5]	4.5[5]	7
Wall bars	—		4.5[5][6]	4.5	4.5

[1] for competitive sport; [2] for school and leisure sport (between fixed apparatus and wall or other fixed apparatus); [3] run-up length 25 m, apparatus length 2 m, run-out length 9 m; [4] distance between centres of ropes 0.5 m; [5] measured either from centres or top of apparatus posts, or end of crossbar, or centre of rope; [6] reduction to 4 m to walls or to 3.5 m to netting walls possible; [7] for national competitions 7 m height is sufficient; A = Austria.

❷ Unobstructed areas and safety distances for fixed sports apparatus

Operational rooms for multi-purpose use (in addition to entrance hall) → p. 350 ❷. Per visitor: 0.1 m². Cloakroom: 1 place per visitor. Per cloakroom place: 0.05–0.1 m² (incl. 1 m of service counter in cloakroom for every 30 cloakroom places). Number of WCs per visitor 0.01, of which 40% WCs for ladies, 20% WCs for gents, 40% urinals.

Storeroom for tables and chairs per visitor: 0.05–0.06 m². Raised stage and associated equipment, per m² stage area: 0.12 m². Cash desk and sundries: as required.

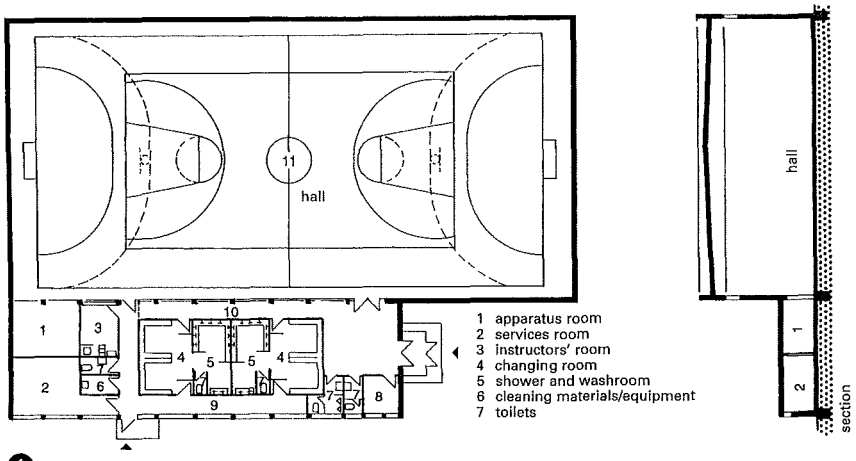
Catering: standing space per vending machine 1.0 × 0.6–0.8 m, tea kitchen 12–15 m², store 6 m², kiosk with drinks 8–12 m², store 10–12 m². Cafeteria/restaurant per seat: 1.5–2.7 m², of which altogether for the guest area 1–1.5 m², for kitchen and stores 0.5–1.2 m². Servery for self-service: per 50 visitor places = 1 m counter. With waiter service: per 100 visitor places = 2 m counter.

Small stage <200 m² → p. 203. Athletes' cloakroom, multi-purpose room for meetings, training, lectures, leisure use. Playroom for board games, billiards etc., reading room and bowling alley as required.

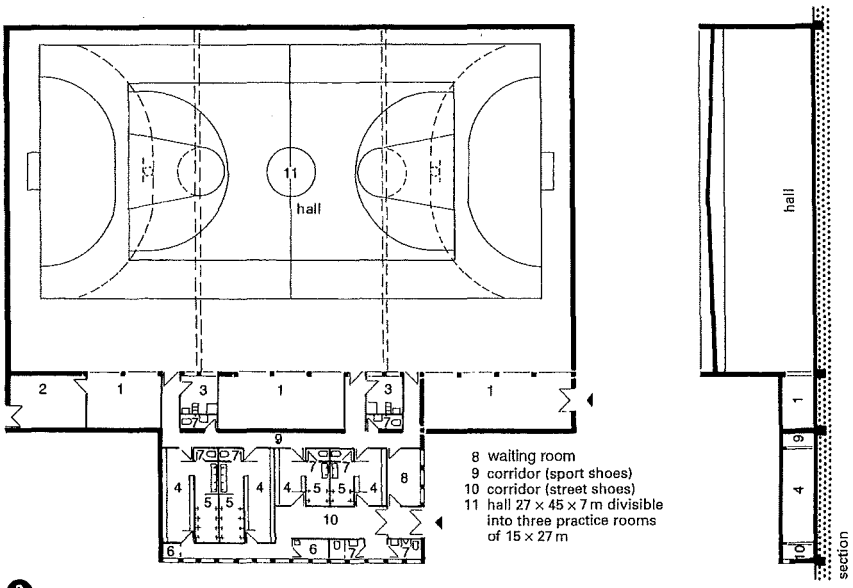
Operations rooms for technical services are included in sports halls. Open-air facilities which do not have a dedicated building must be provided with an equipment room for sports and maintenance equipment in the room arrangements of the sports hall. Open-air sports equipment room = 0.3 m² per 100 m² usable playing area (net area) = 15 m². Maintenance equipment room for hand appliances = 0.04 m² per 100 m²; gross open area = 8 m². Maintenance equipment room for machines = 0.06 m² per 100 m²; gross open area = 12 m². (If maintenance is carried out externally, or else centrally – and the machines are delivered and taken away – the last mentioned room can be omitted.)

SPORTS HALLS

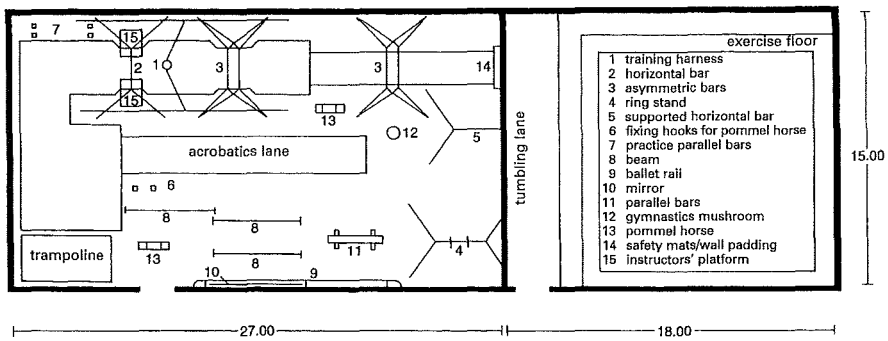
Layout, Construction



1 Schematic plan of sports hall

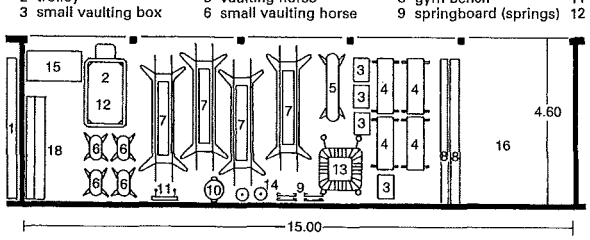


2 Schematic plan of a triple sports hall

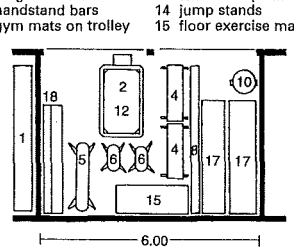


3 Gymnastic apparatus hall 15 × 27 m with floor gymnastics hall 15 × 18 m

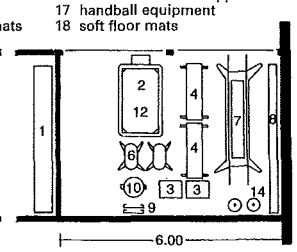
1 equipment cupboard
2 trolley
3 small vaulting box
4 large vaulting box
5 vaulting horse
6 small vaulting horse
7 parallel bars
8 gym bench
9 springboard (springs)
10 magnesia holder
11 handstand bars
12 gym mats on trolley
13 small trampoline
14 jump stands
15 floor exercise mats
16 area for additional apparatus
17 handball equipment
18 soft floor mats



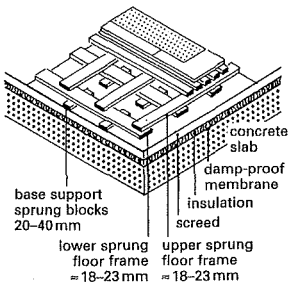
4 Arrangement plan for large equipment in the apparatus storeroom of a 15 × 27 m sports hall



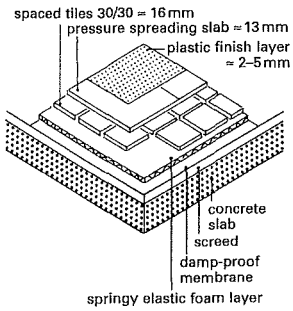
5 Equipment room



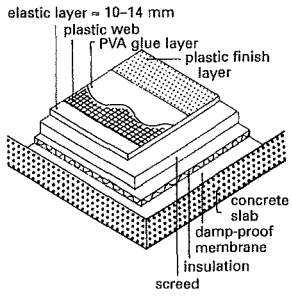
6 Equipment room



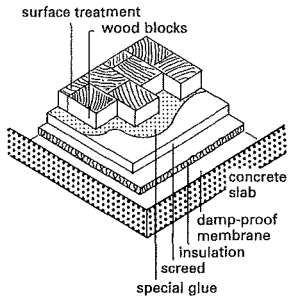
7 Sprung floor construction



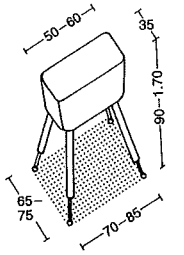
8 Flexible floor construction



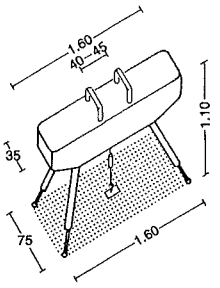
9 Impact-absorbing floor construction



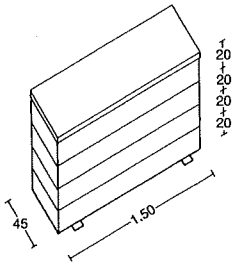
10 Construction detail for wood-block flooring – laid rectangularly with surface treatment



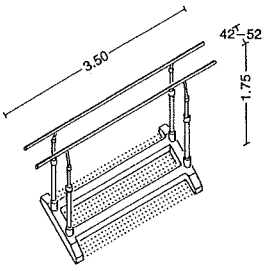
1 Vaulting horse



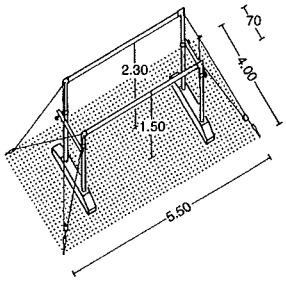
2 Pommel horse



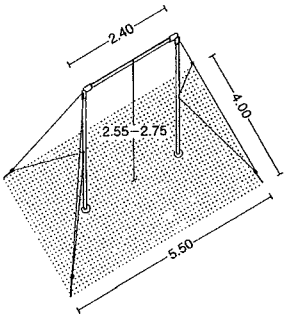
3 Vaulting horse



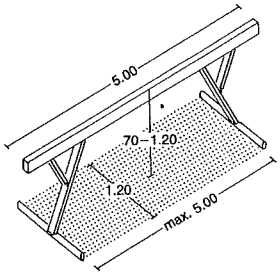
4 Parallel bars



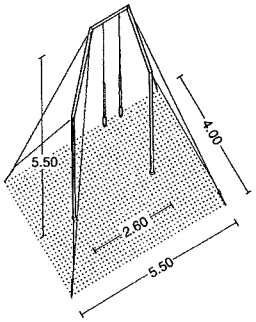
5 Assymetric bars



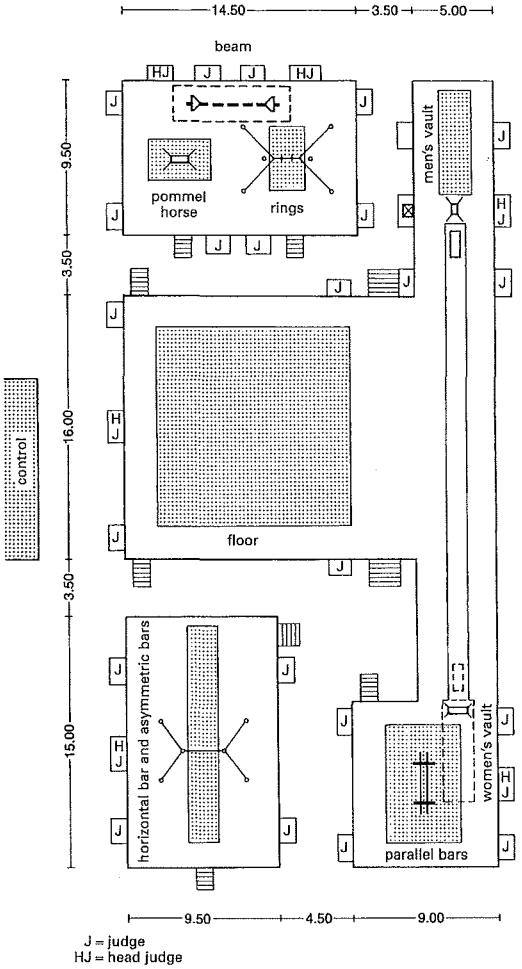
6 Horizontal bar



7 Beam

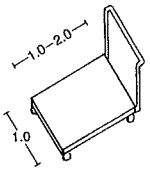


8 Rings support frame

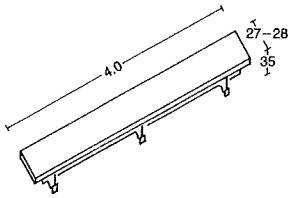


J = judge
HJ = head judge

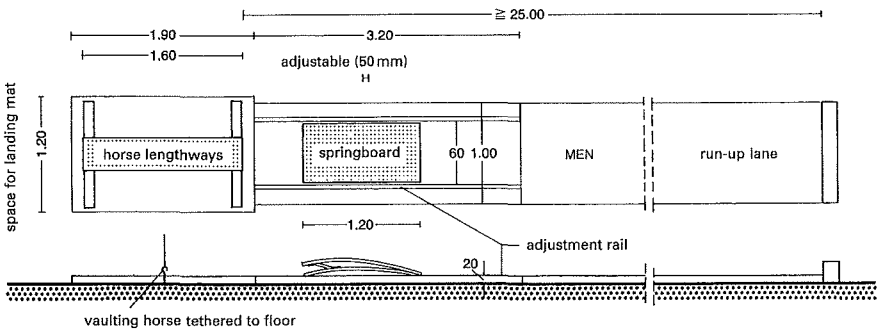
10 Competition podium, space requirements: dimensions of podium, arrangement of judges' places



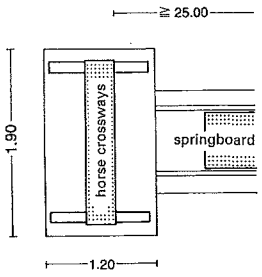
11 Mat trolley



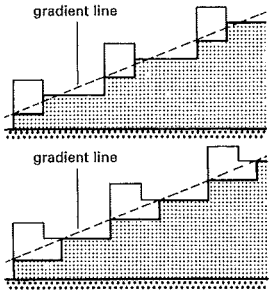
12 Gymnastics bench



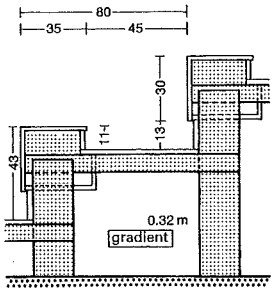
9 Vaulting layout, men



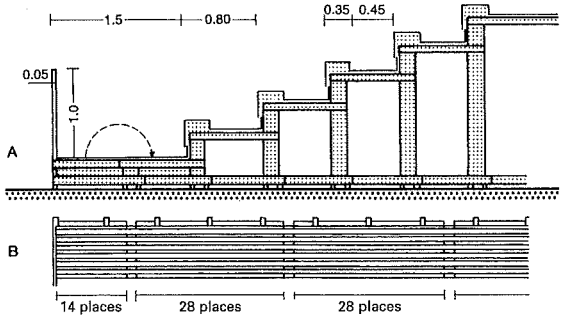
13 Vaulting layout, women



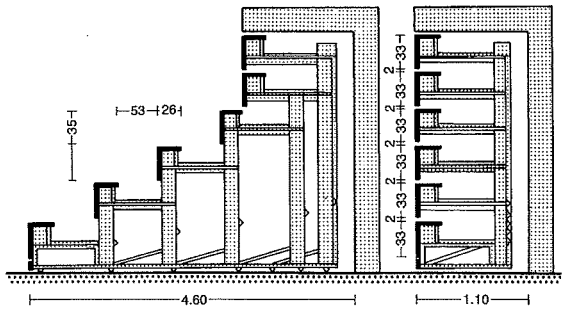
❶ Schematic section through access steps



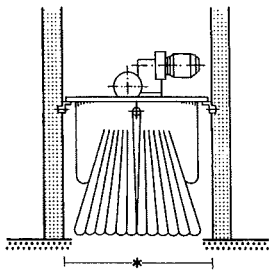
❷ Section through stepped seating with access steps behind



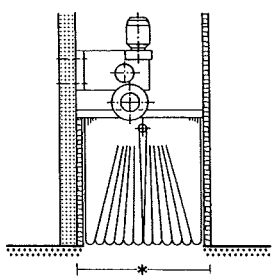
❸ Stand with access from below (A); stand with access from above (B)



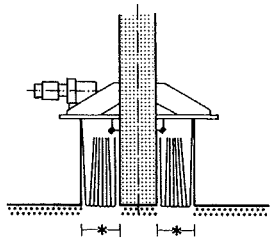
❹ Retractable stand, length ≦6.0 m



❺ Partition curtain between two beams

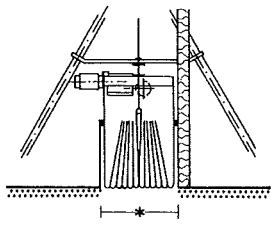


❻ Side view of partition curtain at beam, with sound absorption recess



* – width, depending on height of hall and thickness of material

❼ Partition curtain both sides of a beam



❽ Partition curtain with pulley system mounted in sound-absorbing recess inside a space frame

SPORTS HALLS

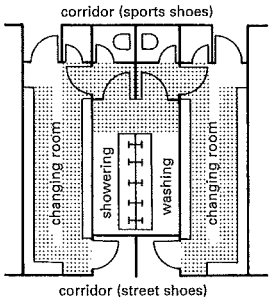
Stands

Spectator stands → ❶ – ❹ can be fixed or mobile. For smaller installations with up to 10 rows of seats, a linear rise of the seats (height 0.28–0.32 m) can be assumed. All other installations should have a parabolic rise (height for seats 1.25 m, standing places 1.65 m), sightline rise for seats 0.15 m, standing places 0.12 m. Row spacing for seats 0.80–0.85 m → ❷ – ❸. For standing places, 0.4–0.45 m. Sightline origin point 0.5 m above the boundary marking of the playing area.

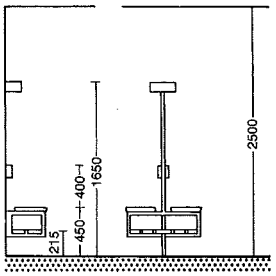
Protect spectator places behind goals with mobile catch nets. Seats in upper levels and galleries should be closed off with nets while practice matches are underway. For the group of rooms including entrance hall, changing and sanitary facilities, teachers' room, additional sport room and hall, it is recommended to arrange a separation of the routeing of people wearing street shoes and sports shoes → ❾ – ⓬. Showers must be immediately accessible from changing rooms, with a drying area between the wet area of the shower room and the changing room. Shower rooms divided into two room units must be connected to the two adjacent changing rooms so that one or both of the room units can be used from either of the changing rooms → ❾ – ⓬. Teachers' rooms should be near the changing rooms. The first aid room must be on the same level as the sports area and can be integrated into the teachers' room.

Spectator stands can generally be accessed from below or above; from below leads to lower costs (spending on stairs and access galleries is saved), but this is disadvantageous for the organisation of events because of visitors passing the base of the stand, disturbing competitors and existing spectators → ❸. Free sides should be protected by ≧1 m high barriers, measured from the traffic surface.

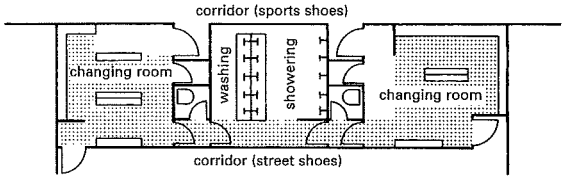
The design of the wall and ceiling area next to the partition must ensure that no noise transfer takes place when the partition is down → ❺ – ❽.



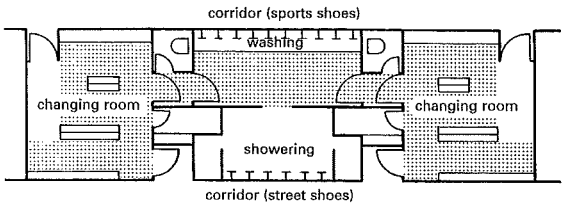
❾ Example 1



❿ Cloakroom seating as wall-mounted and double bench



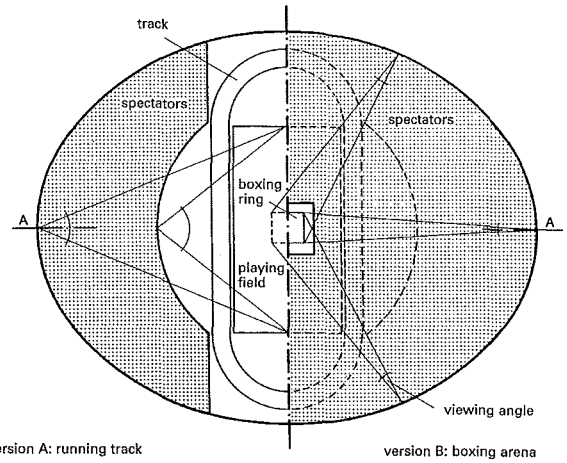
⓫ Example 2



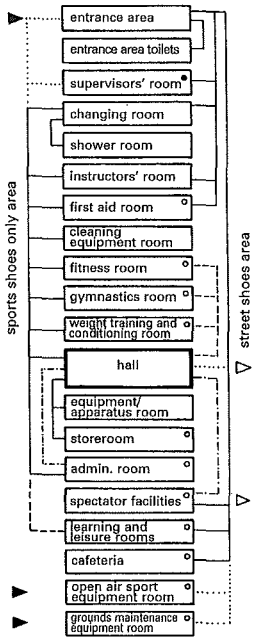
⓬ Example 3 Three proposed solutions for the changing and sanitary facilities (shaded: floor areas laid with PVC grid mats)

SPORTS HALLS

Examples

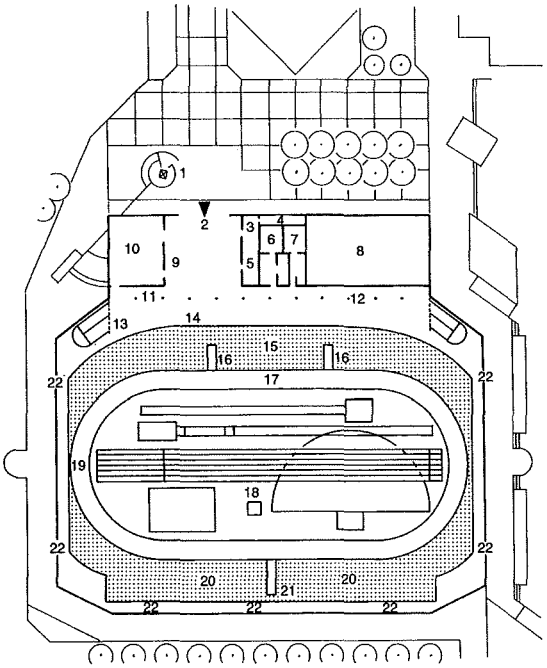


1 Arrangement of spectators

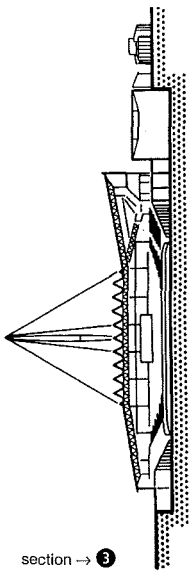


2 Room relationship scheme

key → 2
- ► direct entrance
- ▷ alternative emergency exit
- —— principal connection
- ·—·— visual connection
- – – – alternative connection
- ····· additional connection
- • additional rooms with multipurpose halls
- ○ additional rooms and facilities depending on local situation and need



3 Europa Hall, Karlsruhe, ground floor plan Arch.: Schmitt, Kasimir, Blanke



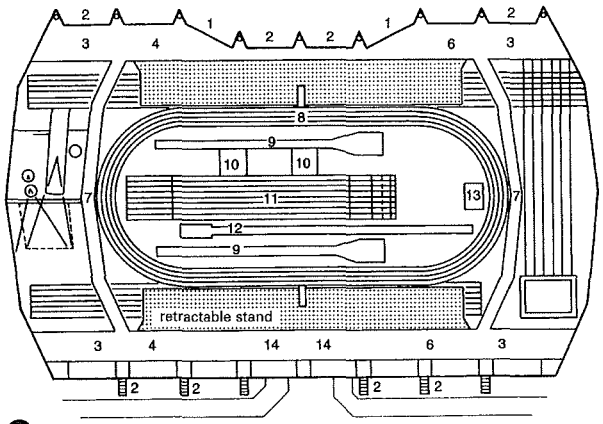
section → 3

key → 3
plan of entrance floor level
1 competitors' access at perimeter level, 2 entrance and foyer for spectators, 3 administration, 4 cash desks, 5 cloakroom, 6 gents' toilets, 7 ladies' toilets, 8 space above warming-up hall, 9 information, 10 training room and lounge, 11 access to basement,12 drinks bar, 13 stairs to balcony, 14 administration room with display and announcements, 15 permanent stand, 16 changing room area/hall connection, 17200 m track, 18 sports hall, 19 large display board, 20 mobile stand, 21 score board, 22 hall perimeter route with emergency exits.

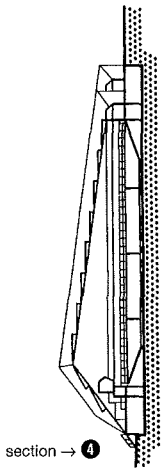
Flexible use of hall is possible → 3

1. Tennis, 2. Handball, 3. Athletics, 4. Boxing, 5. School sport. Ball-catching safety nets at the front separate the interior into four units, each the size of a school sports hall. With warming-up hall in front of the training area 'under' the telescopic stand, the large sports hall offers schools and clubs six practice locations, competition conditions for top-level sport, and practice and training facilities for school and club sport.

Sport-relevant data: → 4 200 m circular track (competition), 130 m + 100 m straight sprint (training) track, 60 m straight sprint (training) track, 400 m stadium curve (training) shot put, discus and high jump facilities.

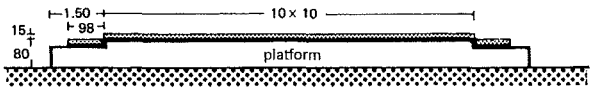


4 Athletics Hall, Dortmund, ground floor plan Design: Hochbauamt Dortmund

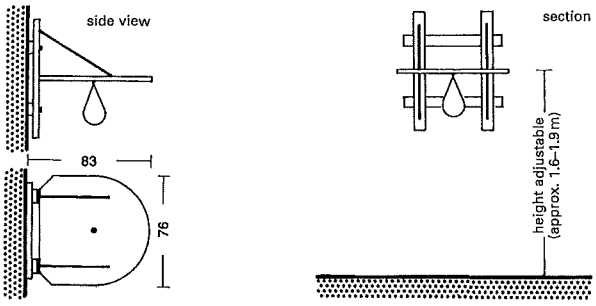


section → 4

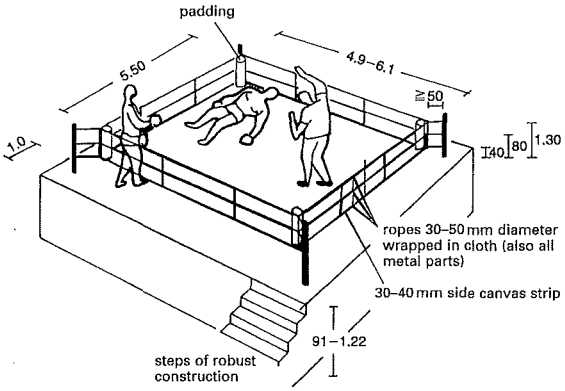
key → 4
plan of entrance floor level
1 entrance hall with cash desks, 2 exits/ emergency exits, 3 foyer, 4 drinks bar, 5 telephone, 6 stairs to spectator toilets, 7 access as bridge over the sports level, 8200 m circular track, 9 pole vault, 10 high jump, 11 sprint competition track, 12 long jump, 13 shot put, 14 stairs up to administration



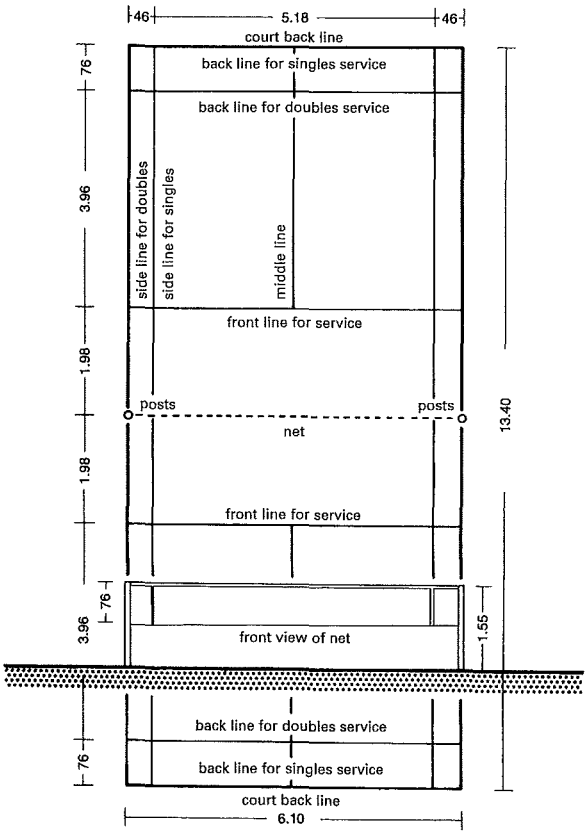
❶ Judo contest area on a platform



❷ Punch ball front view → ❷



❸ Boxing ring



❹ Badminton court

JUDO

Contest area 6 × 6 m to 10 × 10 m or ≧6 × 12 m, covered with soft, springy mats. For German championships and international events, contest area ≧10 × 10 m. Upholstered mats are not allowed. Ideally, the mats should be raised by 15 cm. The separating line between the contest area and the surround should be clearly visible → ❶.

WRESTLING

Mat size for competitions 5 × 5 m; for German championships and international competitions ≧6 × 6 m, possibly 8 × 8 m, for international championships and Olympic games 8 × 8 m. The middle of the mat is marked with a ring of ≧1 m diameter with 10 cm wide edge strip. Mat thickness: 10 cm, soft covering. Surrounding protection strip should if possible be 2 m wide, otherwise boundary tapes at 45° angle. 1.2 m width of the protection strip should be in mat thickness, with colour difference. Protection strip for national competitions 1 m wide. Platform height ≦1.1 m; no corner posts or ropes.

WEIGHTLIFTING

Lifting area 4 × 4 m; ideally with strong timber base, chalk markings, floor should not spring, solid footing for weightlifters.
Largest weight diameter ≧450 mm
Weight for one-handed exercises 15 kg,
Weight for two-handed exercises 20 kg.

BOXING

Dimensions of a boxing ring to international requirements, 4.9 × 4.9 m to 6.10 × 6.10 m. 5.5 × 5.5 m is usual. Raised rings are usual, with a podium 1 m wide on all sides. Entire podium 7.5 × 7.5 m to 8 × 8 m → ❸.

BADMINTON

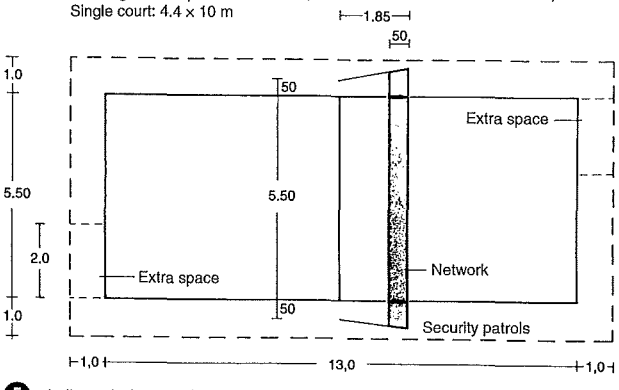
The standard is a doubles court, singles court only if space is lacking.

spacing between courts at side	≧0.30 m
between court and walls	≧1.50 m
backwards spacing between courts	≧1.30 m
safety strip at each side	1.25 m
safety strip front and back, each	2.50 m

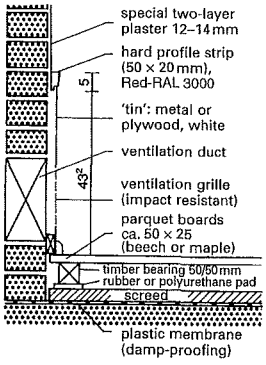
Spectators should be behind the safety strip.

Hall height: 8 m international games, 6 m over rear partition. Net height at posts 1.55 m; in middle 1.525 m, net surface 76 cm high → ❹. Floor covering lightly resilient. Lighting: if possible no windows, but rooflight (glare-free) ≧300 lx.

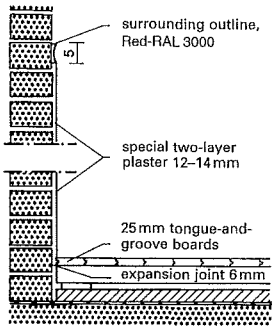
Indiaca volley game: game field dimensions 5.5 × 13.0 m and 9.0 × 18.0 m,
Net height of the post 1.70–2.00 m, 1.68–1.85 m in the network centre,
Single court: 4.4 × 10 m



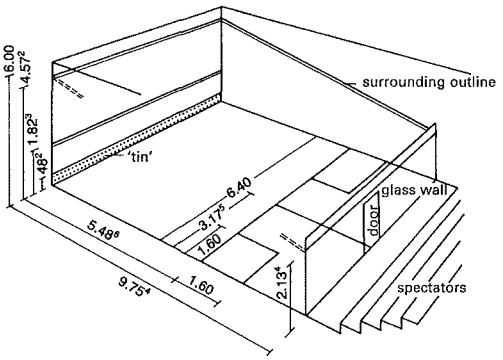
❺ Indiaca playing area (game played using hands and special ball)



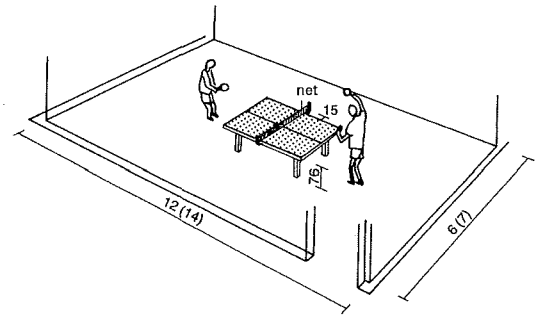
❶ Squash court end wall



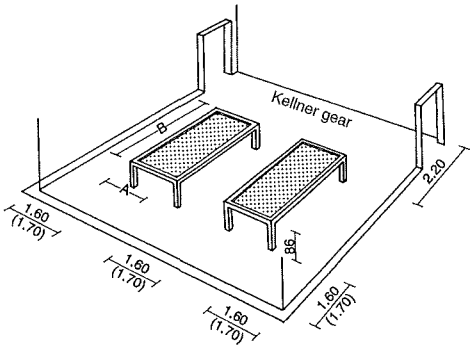
❷ Squash court side wall



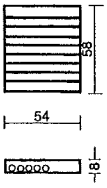
❸ Basic dimensions for squash court



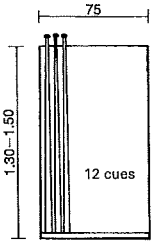
❹ Basic dimensions for table tennis



❺ Basic dimensions and spacings for billiards



❻ Ball cupboard



❼ Cue rack

❽ Usual billiards table sizes

Normal table size (dimensions in cm)		I	II	III	IV	V	VI
internal (playing area)	A	285 × 142[5]	230 × 115	220 × 110	220 × 100	200 × 100	190 × 95
external	B	310 × 167[5]	255 × 140	245 × 135	225 × 125	225 × 125	215 × 120
room		575 × 432[5]	520 × 405	510 × 400	500 × 395	490 × 390	480 × 385
weight (kg)		800	600	550	500	450	350

SPORTS HALLS

SQUASH

The normal construction of squash courts involves massive walls with special plastered surfaces, pre-cast concrete elements, prefabricated panelled timber-framed roof, collapsible seating.

Room size: 9.745 × 6.40 m
Room height: 6.00 m
A glass back wall is advantageous for spectators.

Floor: slightly springy, light wood (maple or beech), good surface slip-resistance, floorboards parallel to the side walls. A practical flooring is tongue and groove parquet strips 25 mm thick and a sealing layer, parquet according to DIN 280 parts 3, 4 and 5.

Walls: Special plaster, flat, white. Strip (the 'tin') running across foot of front wall: of sheet metal 2.5 mm or plywood with sheet metal cladding, painted white → ❶ – ❸.

TABLE TENNIS

At championship level takes place only in halls. **Table surface** horizontal, matt green with white border lines.
Table area ..... 152.5 × 274 cm
Table height ..... 76 cm
Board thickness ..... ≧2.5 cm
For tables in the open air, fibre cement board 20 mm thick.

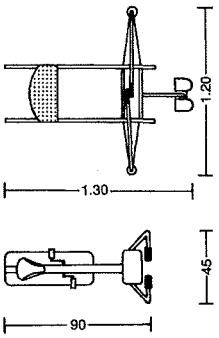
Board hardness: so a normal ball bounces 23 cm when dropped from 30 cm
Net length, centre ..... 183 cm
Net height, entire length ..... 15.25 cm
Playing box (formed by canvas screens 60–65 cm high) ≧6 × 12 m, international 7 × 14 m, spectators beyond screen → ❹.

BILLIARDS

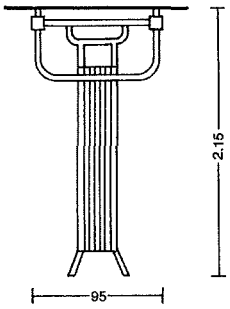
Location of rooms:
First floor or well-lit basement, seldom ground floor.

Space requirement: for the various table sizes → ❺ – ❽.
Common sizes for private purposes ..... IV, V and VI
For cafés and clubs ..... IV and V
In billiards halls and academies ..... I, II and III
Spacing of table sizes I and II from each other ..... ≧1.70 m
Spacing of table sizes III–V from each other ..... ≧1.60 m
and, from the wall, a bit more if possible.
At the side where the waiter passes or the spectators stand, correspondingly more space, plus room for chairs, tables, food and drink (→ pp. 174, 175).
Wall mounting for cue rack and rules of the game.
1 cue rack for 12 cues, overall 150 × 75 cm.

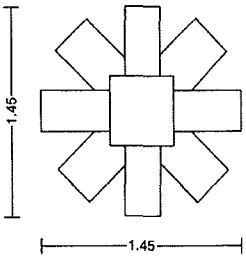
Lighting
The smallest possible lights with full and even light distribution onto the playing area. Usual height for light above table: 80 cm



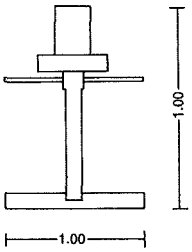
1 Rowing machine and bicycle ergometer



2 Stomach muscle board with push-up bar and wall bars



3 Multi-exercise centre



4 Pulling machine

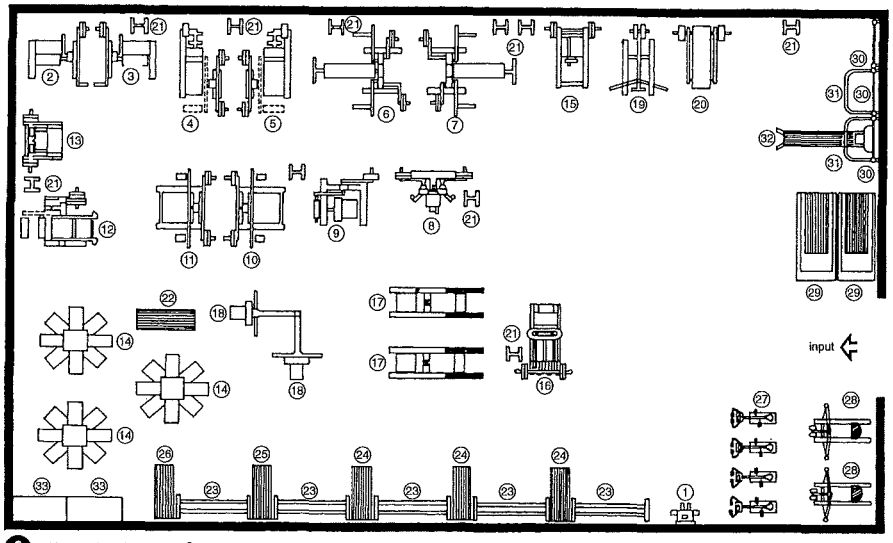
Area	Apparatus or equipment	Exercises	Motor functions	Training intention
A	general training stations	single joint	power flexibility	fitness condition
B	special training stations	many joints	power, speed	fitness condition
C	lifting surface (with multipress or isometric bar)	many joints	power, speed, coordination	condition
D	traditional small apparatus	one and many joints	power flexibility	fitness
E	special training apparatus and open area to warm up (gymnastics etc.)	many joints one and many joints	duration coordination flexibility coordination	fitness condition fitness condition

5 Categories of machine by use

Area	Conditioning room 40 m²	80 m²	200 m²	Equipment list
A			1	1 hand roller
		2/3*	2	2 biceps station
			3	3 triceps station
		4/5*	4	4 pull-over machine I
			5	5 pull-over machine II
		6/7*	6	6 Latissimus machine I
			7	7 Latissimus machine II
		8	8	8 chest station
		9	9	9 torso station
		10/11*	10	10 hip station I
			11	11 hip station II
		12	12	12 leg station
		13	13	13 foot station
	14 (2 x)		14 (3 x)	14 multi-training centre
B			20	20 press apparatus I
			23	23 leg press
		25	25 (2 x)	25 stomach muscle station
		26	26 (2 x)	26 pulling machine
			27	27 press-up apparatus
			33	33 Latissimus floor bells
C		43 (4 x)	43 (10 x)	43 small disc stand
	46 (2 x)	46 (2 x)	46	46 training bench
D	50	50	50 (3 x)	50 hand dumbbells
	51	51	51 (3 x)	51 short dumbbells
	52	52	52 (5 x)	52 short dumbbell stand
			53	53 exercise dumbbell rod
		56		56 press bench
		57	57 (3 x)	57 sloping bench I
		58		58 sloping bench II
			59	59 all-round bench
		60	60	60 multi-training bench
		61		61 compact dumbbell
		62		62 dumbbell stands
E	70 (3 x)	70	70 (4 x)	70 cycle ergometer
	71 (2 x)	71 (3 x)	71 (2 x)	71 rowing machine
	72		72 (2 x)	72 running belt
	73	73 (2 x)	73 (3 x)	73 wall bars
	74	74 (2 x)	74 (2 x)	74 press-up bar
	75	75	75	75 stomach muscle board
		78		78 punch ball
	79 (2 x)	79 (2 x)	79 (3 x)	79 expander-impander
	80 (2 x)	80 (2 x)	80 (2 x)	80 skipping rope
	81 (2 x)	81 (2 x)	81 (3 x)	81 Deuser band
	82 (2 x)	82 (2 x)	82 (3x)	82 finger dumbbells
	83 (2 x)	83 (2 x)	83 (3 x)	83 Bali machine
		85 (2 x)	85 (3 x)	85 hydro-dumbbell
	89	89	89 (2 x)	89 equipment cupboard

* Apparatus 2 and 3, 4 and 5, 6 and 7, 9 and 10 and are available in very different versions and should therefore be provided to suit the number of dumbbells and weights to be chosen: 7 as well as 10 and 11 can be used for two functions from various manufacturers.

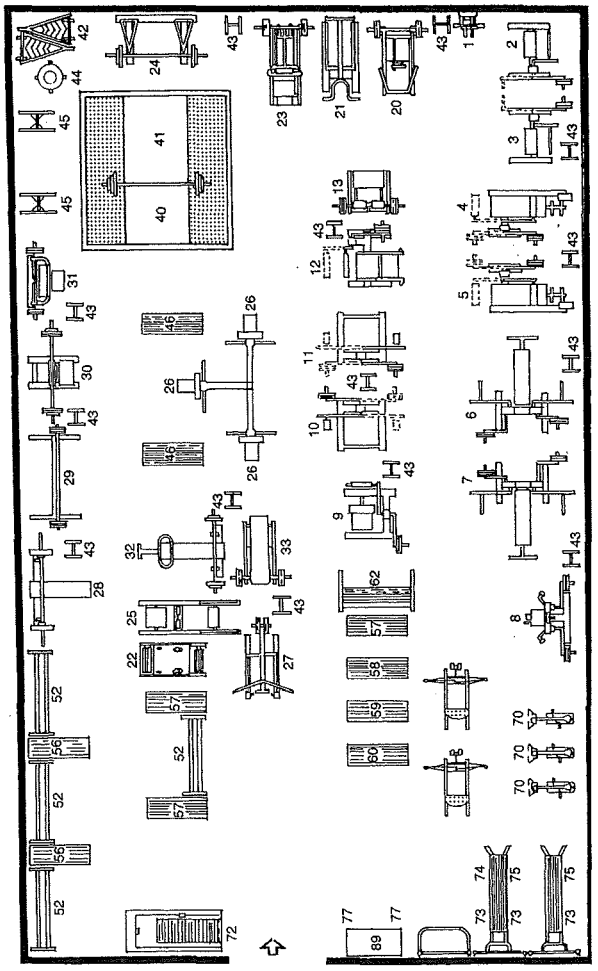
7 Equipment suggestions for fitness rooms



6 Example of a 200 m² fitness room

1 hand roller
2 biceps station
3 triceps station
4 pull-over machine I
5 pull-over machine II
6 Latissimus machine I
7 Latissimus machine II
8 chest station
9 torso station
10 hip station I
11 hip station II
12 leg station
13 foot station
14 multi-training centre
15 press apparatus I
16 leg press apparatus I
17 stomach muscle station
18 pulling machine
19 press-up apparatus
20 Latissimus floor bells
21 small disc stand
22 training bench
23 short dumbbell stand
24 sloping bench I
25 all-round bench
26 multi-training bench
27 cycle ergometer
28 rowing machine
29 running belt
30 wall bars
31 press-up bar
32 stomach muscle board
33 equipment cupboard

Room size for 40–45 people min. 200 m² → ❷, clear ceiling height for all rooms 3.0 m. Conditioning and fitness rooms should generally be 6 m wide for an optimal arrangement of machines in two rows. Room length ≦15 m, otherwise there is no overview while training. The smallest room unit of 40 m² is suitable for 12 users.



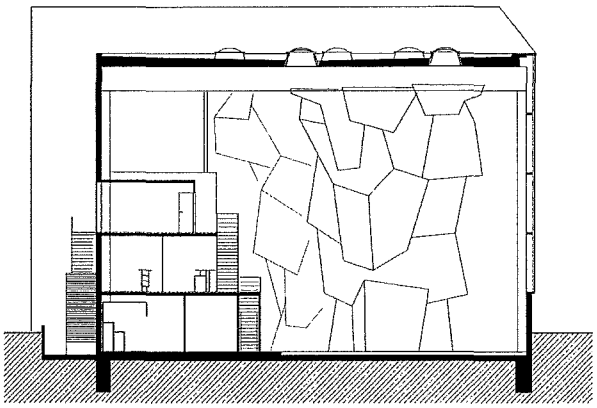
❷ Example of 200 m² conditioning room

Area	Machine no.	Description	Movements	Space (cm)
A	1	hand roller	hand bends, hand stretching	60/30
	2	biceps station	arm bends	135/135
	3	triceps station	arm stretching	135/135
	4	pull-over machine I	arm lifting in front of the body	190/110
	5	pull-over machine II	arm lowering in front of the body	190/110
	6	Latissimus machine I	sideways arm lowering and lifting	200/120
	7	Latissimus machine II	bring arms together and apart in front of the body	200/120
	8	chest station	bring arms angled together in front of the body	165/100
	9	torso station	stretch and bend torso	135/125
	10	hip station I	lift and lower legs	175/125
	11	hip station II	lift and retract legs	175/125
	12	leg station	stretch and bend legs	125/155
	13	foot station (calves apparatus)	stretch and bend feet	140/ 80
	14	multi-exercise centre	various leg and multi-joint movements	various
B	20	push apparatus I	arm stretching, horizontal (standing)	120/140
	21	push apparatus II	arm stretching, vertical and/or calf training (standing)	70/160
	22	Hackenschmidt apparatus	leg stretching on slope	90/140
	23	leg-press apparatus	leg stretching, horizontal (sitting)	120/160
	24	knee-bend apparatus (with weights)	leg stretching, vertical (standing)	200/ 90
	25	stomach muscle station	various exercises for stomach and back muscles	65/200
	26	pulling machine	various single and multi-joint basic movements	100/140
	27	press-up apparatus	arm bends and arm stretching, vertical (hang or push-up)	120/155
	28	press bench I	arm stretching, vertical (lying bench pressing)	200/120
	29	dumbbell apparatus (multipress machine)	bench press, knee bend, standing presses and pull exercises (all with weights)	200/100 185/100
	30	press bench II (sloping bench for long dumbbell)	sloping bench presses (sitting)	150/ 70
	31	curl bench	arm bends	
	32	press bench III	bench press (on back sloping downwards)	160/170
	33	Latissimus floor dumbbell	arm bends, pull in with forward torso	120/130
C	40	lifter bed with rubber inserts	all exercises with free dumbbell (knee bend, press and impact)	300/300
	41	practice dumbbell bar		200
	42	large weight stand		50/100
	43	small weight stand		30/30
	44	magnesia container		0/38
	45	knee-bend stand (in pairs)		35/70 ea.
	46	training bench		40/120
	47	full-rubber mixed weights (10; 15; 20; 25 kg)		
	48	weights with vulcanised rubber edge (15; 2; 25 kg)		
	49	cast weights (1.25; 2.50; 5; 10; 25; 50 kg)		
D	50	hand dumbbell (1; 2; 3; 4; 5; 6; 8; 10 kg)	various single and multi-joint exercises with hand, compact and long dumbbells	
	51	short dumbbells (2.5; 5; 7.5 etc. – 30 kg		
	52	short dumbbell stand		140/130
	53	training dumbbell bar		185
	54	knee-bend bar		200
	55	(upholstered) curl bar		
	56	press bench (adjustable)		140
	57	sloping bench I		40/120
	58	sloping bench II		40/120
	59	all-round bench		40/120
	60	multi-training bench (12-fold adjustable)		40/120
	61	compact dumbbell (2–60 kg)		
	62	dumbbell stand		145/80
E	70	cycle ergometer	endurance, coordination; nos. 70–76	40/ 90
	71	rowing machine	arm bends	120/140
	72	running belt		80/190
	73	wall bars		100/15
	74	press-up bar for wall bars		120/120
	75	hanging stomach-muscle board		100/180
	76	spine relief apparatus	flexibility, coordination, nos. 77–88	70/150
	77	jumping power tester		
	78	punch ball		
	79	expander-impander		
	80	skipping rope		
	81	Deuser band		
	82	finger dumbbell		
	83	Bali machine		
	84	ball dumbbells		
	85	hydro-dumbbells		
	86	weight vests		
	87	weight bags for arms/legs		
	88	mirror		
	89	equipment cupboard		50/110

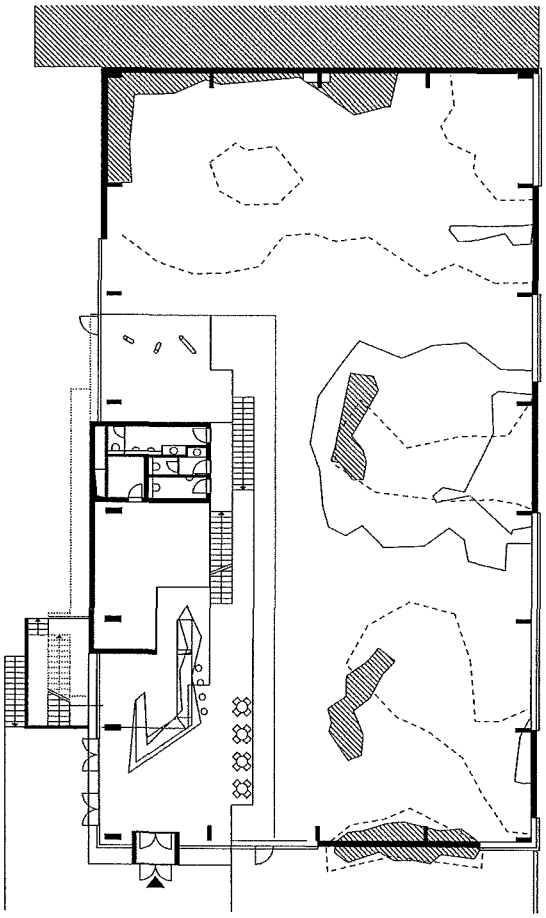
❶ List of machines and apparatus for conditioning and fitness training

Construction	Description	Properties
solid concrete (formwork)	compact standing concrete panels with positive and negative structures	sharp edges, additional grips, variable surface design is possible
shotcrete	mesh of steel wires (reinforcement) sprayed with concrete.	organic shapes can be bolted on subsequently, only for outdoor walls
timber	timber-based boards with or without coating bolted directly to an internal wall or onto a support construction	install numerous drilled holes. Projecting and recessed grips can be installed cheaply
GRP (glass fibre-reinforced plastic)	boards or various shapes made of GRP can be bolted directly to an internal wall or onto a support construction	natural surface, various surface-fixed or recessed grips are possible. Disposal could be a problem

❶ Climbing wall construction types (Deutcher Alpenverein → refs)



❷ Magic Mountain climbing hall, Berlin, section Arch.: Gantz Weber Architects



❸ Magic Mountain climbing hall, Berlin, ground floor
Arch.: Gantz Weber Architects

Climbing halls make climbing possible all year round, whatever the weather. The size and shape of halls is variable depending on the operator's ideas and space available (up to 2500 m² indoor area).

Concentrating the subsidiary functions is practical in order to keep a large part of the area for climbing. The entrance with reception and cash desk can be supplemented by a cafeteria and shop for climbing equipment.

Sanitary facilities are similar to those in a fitness centre. Sensible additions would be a steam bath/sauna with rest zone, possibly also a fitness area.

A high degree of daylight is desirable (smoke extraction domes as daylight sources) and artificial light should only be indirect to avoid dazzling of climbers and safety staff. Climbing walls must be regularly maintained by an expert according to the manufacturer's recommendations.

Types of climbing wall:

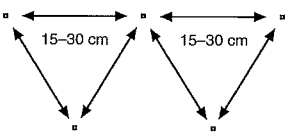
Boulder wall: This is climbed at low height without safety ropes. The climbers move horizontally ('traverse') or 'boulder' short stretches upwards. The wall can be climbed without supervision. There must be a jumping-off area of gravel, bark mulch or mats.

Top rope or **lead wall:** Roping is necessary on account of the height. The climbers mainly climb upwards and, at the top of the wall, are let down by a climbing partner or abseil themselves. It is also possible to boulder at the foot of this wall and it must be secured against unsupervised climbing. No grip should be reachable up to a height of 2.5 m. If a top rope or lead wall is in a sports hall, the requirements for sport operation in sports halls still have to be met (e.g. impact protection)

Climbing walls are modelled on natural rock faces in their surface and design. The colour scheme is variable and often in accord with a CI scheme. Dimensions and shape are flexible. The height for sport climbing is up to 18 m, exceptionally to 30 m. Climbing walls are built by specialist firms and are offered as a building-block system or as a free design of the climbing area.

The support construction (steel or wood) must support itself or be extended from the hall construction, with cladding of various materials → ❶. Various grip and step elements can be screwed to these types of climbing wall. The climbing grips are made of a resin mix with quartz sand dusting and are fixed to the wall with M10 Allen bolts. The types range from 3 cm to beer crate size. Grips of various colours can mark different 'colour' routes. The combination of various colours in one route enables a number of routes on the same section of wall. The number of grips per m² should be in accordance with the intended user group.

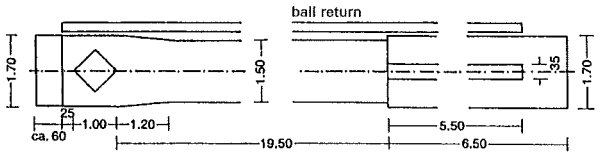
An ideal layout provides differentiated areas for beginners and experts, and separate areas for children.



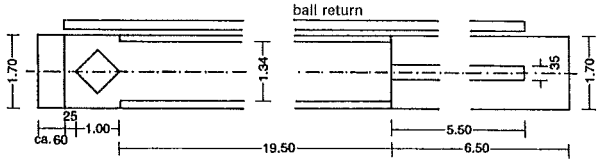
❹ Grip pattern staggered (or square) (Deutcher Alpenverein → refs)

Climbing standard	Children, young people	Adult beginners	Normal	Training
grips/m²	8–10	4–8	3–5	>10

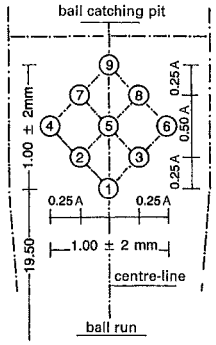
❺ Number of grips/m² according to user group (Deutcher Alpenverein → refs)



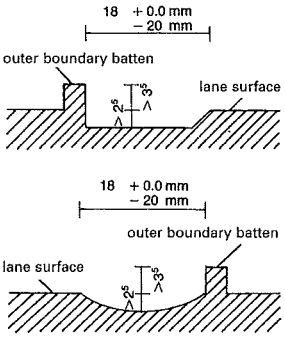
❶ Construction of lane with side bands



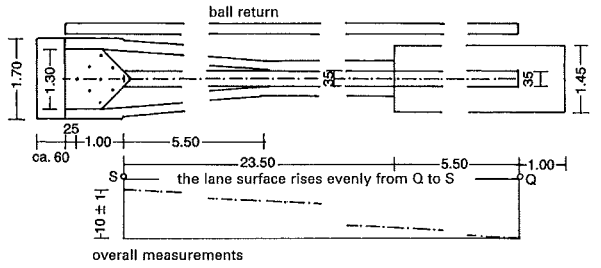
❷ Construction of lane with side channels



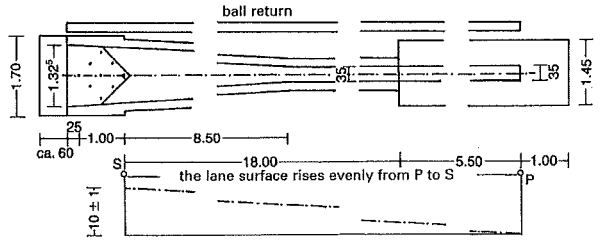
❸ Arrangement and description of pins



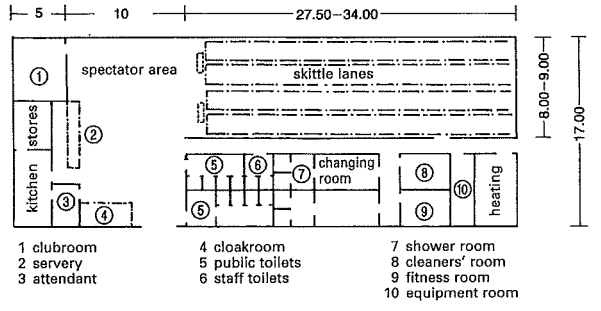
❹ Possible designs for side channel



❺ Planked lane



❻ Layout and main dimensions of tapered lane



❼ Example of a bowling alley

A bowling alley contains the following areas:
1. Run-up area, where the ball is rolled after a few steps.
2. Lane, the actual rolling area of the ball.
3. Catching area, where the pins stand and where fallen pins and the bowling ball are collected.

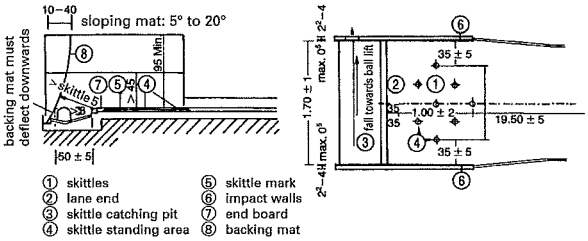
Asphalt track is a specific sporting track and places the highest demands on the bowlers because of its particular surfacing. The lane is 19.50 m long and 1.50 wide (with side strips) or 1.34 m (side bordered by gutter) asphalt or plastic lane → ❶ – ❹.

Planked lane was originally a timber bowling lane, but may also be constructed of plastic → ❺. The particular feature is the rise of 10 cm, measured from the bowling position to the first pin. The lane is 23.50 m long and 0.35 m wide with elevated edges.

Tapered (or scissor) lane is also a timber bowling lane (or plastic) → ❻. The lane widens after 9.5 m to 1.25 m at the centre of the pins.

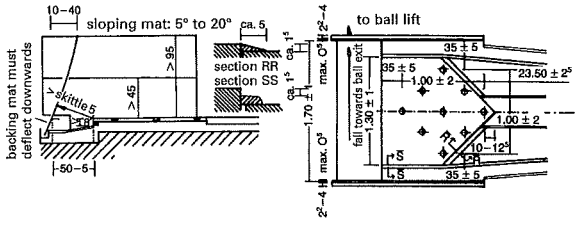
In bowling alleys → ⓬ the run-up area is made of cleanly sanded parquet over the entire width (1.041–1.065 m). The lane is polished or varnished parquet. The bowling balls are 21.8 cm with a maximum weight of 7257 g, with three finger holes.

On asphalt and tapered lanes, balls are of diameter 16.5 cm, weighing ≧2800–2900 g. Planked lane balls are 16.5 cm, ≧3050–3150 g. The balls are made of plastic mixture and the pins of hardwood (beech) or plastic with standardised sizes. Pins are also made of plastic-coated wood or plastic, also standardised.



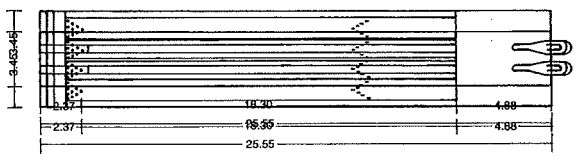
❽ Section → ❾

❾ Standard pin area

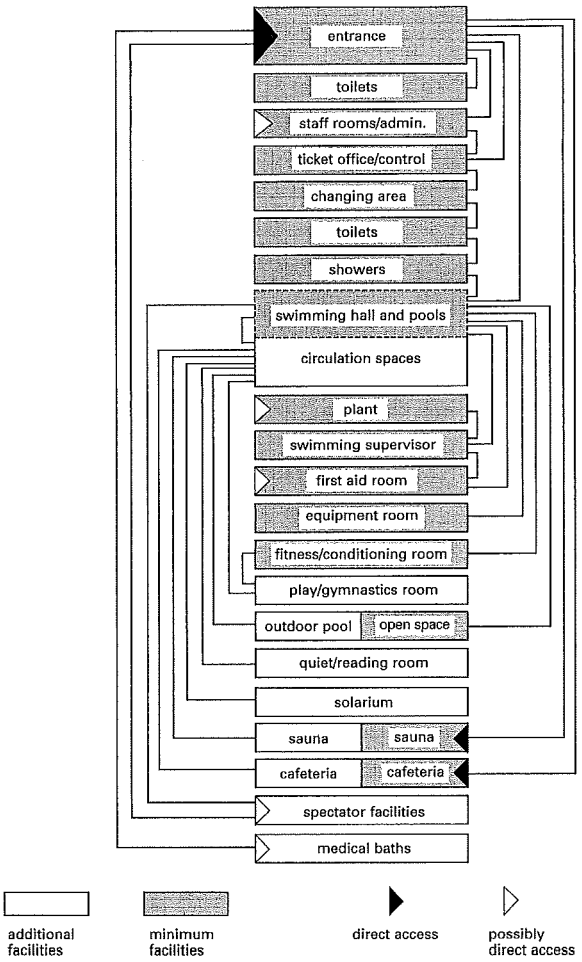


❿ Section → ⓫

⓫ Pin area



⓬ Double bowling lane



1 Indoor swimming pool – room relationship scheme

The size of an indoor swimming pool building depends on the size of the pool/water area (or the dimensions of the basin and the diving boards), the surrounding areas, additional facilities and required room heights.

Building plot

For indoor pools (without parking) allow a plot size of 6–8 m^2 per m^2 of planned pool area; if the water area is very large, a smaller value will suffice. Additional open-air areas (terraces, sun decks, sunbathing lawns) can add about 10–20% to the total plot size.

A building plot which is flat or with a max. slope of 15° enables the design of a public indoor pool on one level, which is a precondition for an economically and functionally optimised design. A greater slope to the terrain will lead to higher building costs or functional disadvantages.

Parking

1 car parking space per 5–10 clothes lockers for the swimming pool.

1 bicycle space per 5 clothes lockers for the swimming pool.

If there are facilities for spectators: 1 additional parking space for every 10–15 spectators. If catering is included: 1 additional parking space for every 4–8 seats.

Subsidiary spaces

The **total water area** serves as the basic value for determining the subsidiary rooms. With leisure pools this value should be supplemented to take additional functions into consideration.

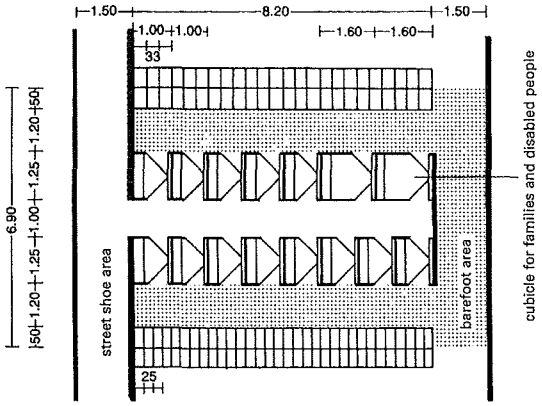
Area in front of entrance: 0.2 m^2/m^2 of water area.

Entrance hall: floor area 0.15–0.25 m^2/m^2 of water area, depending on the pool size and the leisure orientation. Also 5 m^2 wind lobby, 5 m^2 cash desk or automated paying area, 1–2 m^2 cleaning room and toilets (1 WC each for ladies and gents).

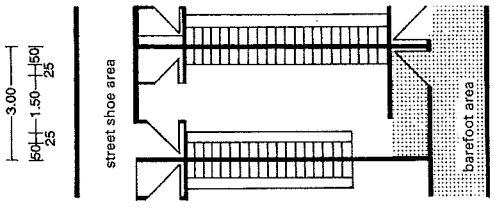
Total water area (WA) (m^2)	Pool types[1]	Example 1		Example 2		Example 3		Diving facilities[2]	Plot area without parking (m^2)[3]
		Pool size (m or m^2)	WA (m^2)	Pool size (m or m^2)	WA (m^2)	Pool size (m)	WA (m^2)		
1	2	3		4		5		6	7
up to 300	CP PP	10.00 × 25.00 approx. 15	250	—		—		1 B + 3P	approx. 2500
up to 450	CP NSP PP	10.00 × 25.00 8.00 × 12.50 approx. 20	250 100 20	10.00 × 25.00 8.00 × 12.50 approx. 20	250 125 20	12.50 × 25.00 8.00 × 12.50 approx. 20	313 100 20	1B + 3B	approx. 3000–3500
up to 600	CP	12.50 × 25.00	313	12.50 × 25.00	313	12.50 × 25.00	313	for CP: 1 B + 3 B or 1 B + 3 B + 1 P	3500–4000
	NSP DP PP	8.00 × 12.50 approx. 25	100 25	8.00 × 16.66 approx. 25	133 25	8.00 × 12.50 10.60 ×12.50 approx. 25	100 133 25	+ 3 P + 5 P for DP: 1 B + 1 P comb. +3 B + 3 P comb. + 5 P	
up to 750	CP NSP DP[4] PP	12.50 × 25.00 8.00 × 12.50 10.60 × 12.50 approx. 30	313 100 133 30	12.50 × 25.00 8.00 × 16.66 10.60 × 12.50 approx. 30	313 133 133 30	16.66 × 25.00 8.00 × 16.66 12.50 × 11.75 approx. 30	417 133 147 30	for CP and DP: 1 B + 1 P comb. + 3 B + 3 P comb. + 5 P or: 1 b + 3 B + 1 P + 3 P + 5P	4000–4500
up to 800	CP NSP DP[4] PP	16.66 × 25 8.00 × 16.66 12.50 × 11.75 approx. 35	417 133 147 35	16.66 × 25 8.00 × 16.66 16.90 × 11.75 approx. 35	417 133 199 35			for CP and DP: 2 × 1 B. 2 × 3 B 1 P + 3 P + 5 P or: 1 B + 3 B + 1 P + 3 P +	approx. 5000

Notes: [1] Abbreviations: PP = paddling pool; NSP = non-swimmer pool; CP = combined pool; DP = diving pool.
In special cases, a swimmers' pool (SP) can be provided instead of a combined pool (CP).
[2] Abbreviations: B = board; P = platform; 1–10 = diving height (m); WA = water area.
[3] Recommended plot sizes
[4] Dimensions under consideration of safety/measurements
Pool size = pool width (diving board side) × pool length in diving direction

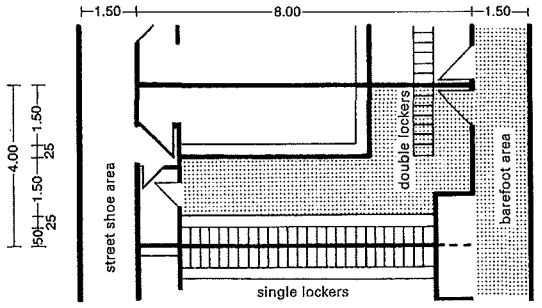
2 Design examples for indoor swimming pools (division of the water area between swimmers and non-swimmers approx. 2:1)



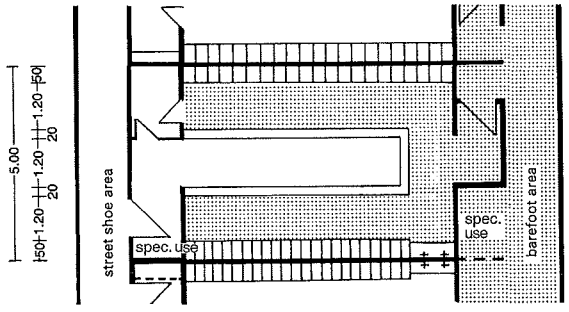
❶ Changing area: cubicles with clothes locker



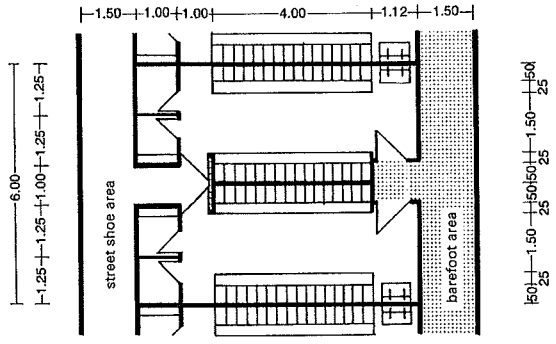
❷ Communal changing room: without shoe-removal bench



❸ Communal changing room: without shoe-removal bench



❹ Communal changing room: with shoe-removal bench



❺ Changing area: mixed type

Changing area

The size of the changing area can be derived from the water area (m^2). Rough estimate for a swimming time of about 1.5 hours: no. cloakroom places = 0.3–0.4 m^2 water area. No. changing places: 0.08–0.1 m^2 water area, of which 40–50% as cubicles, the rest as changing benches in communal rooms. Ratio of changing places to clothes lockers 1:4.

Family or wheelchair cubicles: 10% of the cubicles

No. communal changing places: min. 2; each communal changing place with min. 30 clothes lockers.

Dimensions

Minimum dimensions of installed fittings:

Cubicle: axis dimensions 1.00 m wide, 1.25 m deep, 2.00 m high.

Family changing cubicle: internal dimensions 1.60 m wide, 1.25 m deep, 2.00 m high.

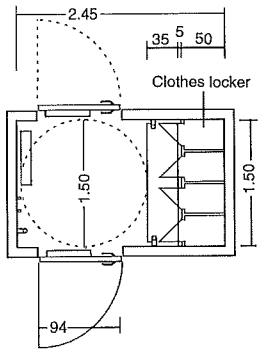
Changing cubicle for wheelchair users: internal dimensions 2.45 m wide, 1.50 m deep, 2.00 m high, clear door width 0.94 m → ❻ – ❼.

Clothes locker → ❽ 0.25 m or 0.33 m wide (axis dimensions), 0.50 m deep (clear), 1.80 m high for full-height lockers or 0.90 m high for stacked lockers. For wheelchair users, the lockers are 0.40 m wide and should be provided only as full-height lockers in order to be able to house walking aids etc.

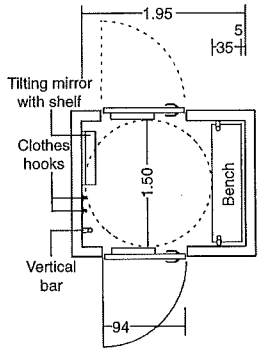
Changing bench: 0.20–0.25 m seat depth, for wheelchair users 0.40 m seat depth, 0.45 m seat height. Min. 7.50 m bench length in communal changing rooms (for school use min. 10.00 m).

No. **sanitary fittings per guideline unit**: 0.03 hair care places with dryer, 0.015 foot disinfection points, 0.015 bucket sink, cleaning equipment room 1–2 m^2, near changing area. Ceiling height 2.50 m.

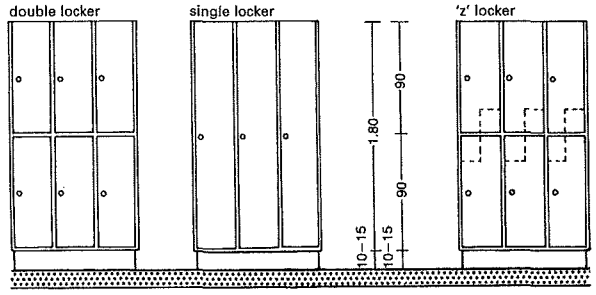
Foot disinfection point (traffic area): 0.75 m wide, 0.50 m deep.



❻ Wheelchair-accessible changing cubicle: with clothes lockers



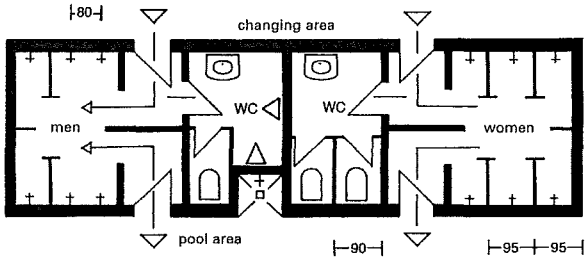
❼ Wheelchair-accessible changing cubicle: without clothes lockers



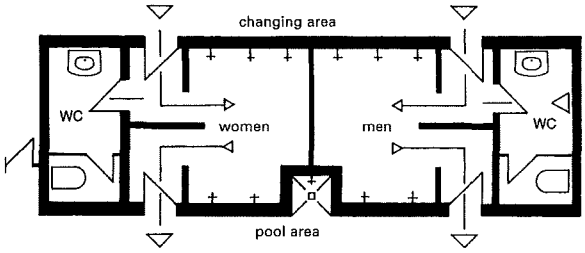
❽ Clothes lockers: details (examples)

SWIMMING POOLS

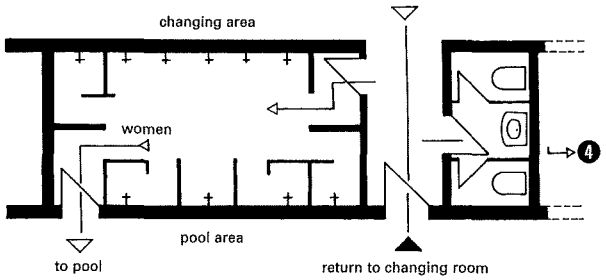
Indoor Public Pools



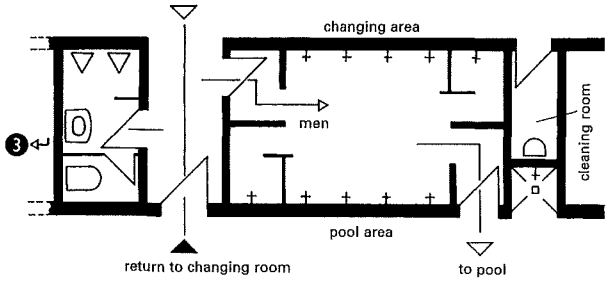
❶ Scheme of sanitary facilities



❷ Scheme of sanitary facilities with divided shower room



❸ Sanitary facilities (example ladies)



❹ Sanitary facilities (example gents)

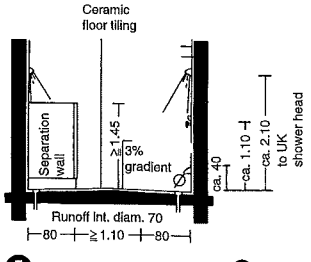
The **sanitary facilities** include showers and toilets, ladies' and gents' separated. Location should be between the changing and the pool areas. The toilets should be arranged so that, after use and before entering the pool area, the bather has to cross a shower room → ❶ – ❹. A direct route back from the pool area to the changing area is definitely to be recommended.

Size of the sanitary facilities: basic equipment min. 1 shower room each for ladies and gents with min. 10 showers (applies for water area up to 500 m^2). In addition, a further shower should be provided for every 25–50 m^2 of water area. In indoor swimming pools in schools up to 150 m^2 water area, 1 divisible shower room each for girls and boys with 5 showers is sufficient → ❷.

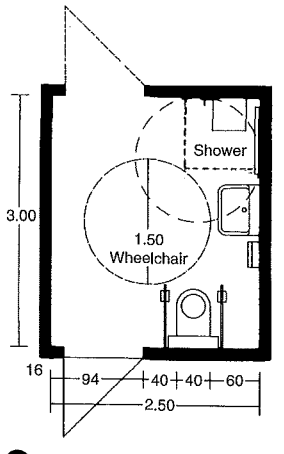
Toilets: each shower room requires 2 WCs for ladies, 1 WC and 2 urinals for gents → ❶.

Minimum dimensions of movement areas in sanitary facilities:

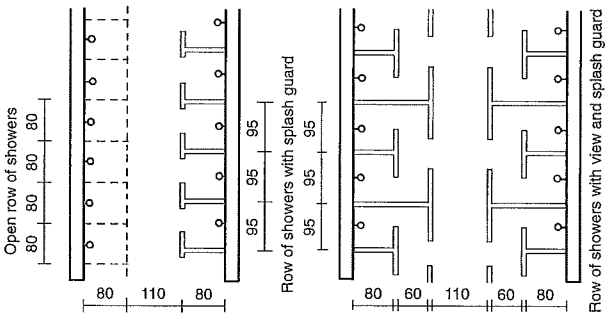
shower without partition:	0.80 m wide
(open row of showers)	0.80 m deep
shower with partition:	0.95 m or
(row of showers with spray guard)	0.80 m wide
	1.45 m high
shower with double-T partition:	0.80 m or
(with spray and sight partition)	0.95 m wide
	1.40 m deep
	1.45 m high
corridor width between two rows of showers:	1.10 m
toilet with inward opening door	0.90 m wide
	1.40 m deep
	2.00 m high
toilet with outward opening door:	0.90 m wide
	1.20 m deep
	2.00 m high
urinal (axis dimensions):	0.65 m
free standing area:	0.40 m
installation height:	approx. 0.70 m
installation height for children:	approx. 0.50 m
washbasin (axis dimensions):	approx. 0.70 m
free standing area:	approx. 0.60 m
installation height	approx. 0.80 m
minimum clear ceiling height	2.50 m
recommended	2.75 m



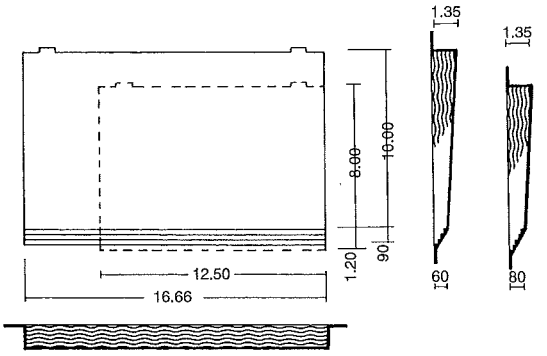
❺ Shower room (scheme) → ❸



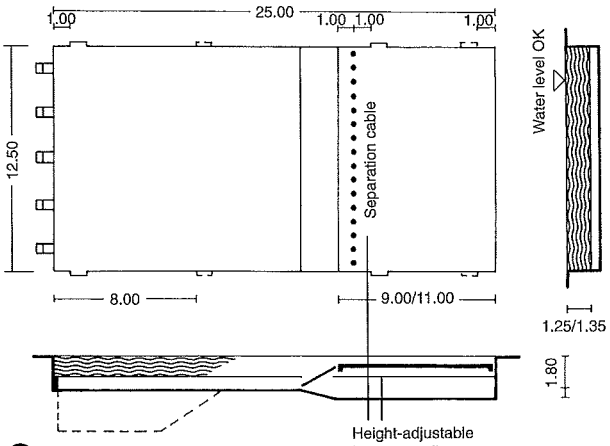
❻ Sanitary unit for wheelchair users



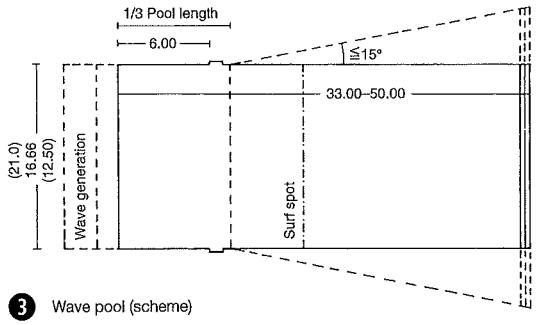
❼ Shower and partition arrangement



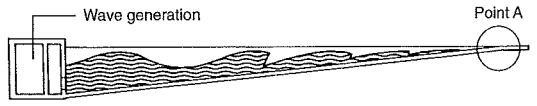
1 Scheme of non-swimmers' pool, plan and section



2 Variopool 25.00 m

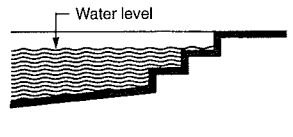


3 Wave pool (scheme)

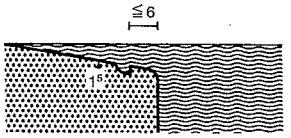


4 Section of wave pool

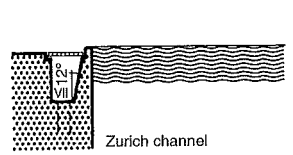
5 Section of combined swimmers' and wave pool

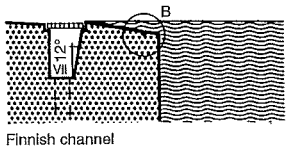


6 Variant of point A with steps



7 Point B → 8 (Finnish channel)





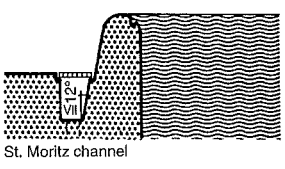
8 Examples of overflow channels

Pool area

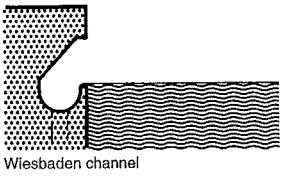
Pool	Width (m)	Length (m)	Water depth, remarks	Min. ceiling height
paddling pool	min.15	25 m²	0.00–0.40/60	2.50 m
non-swimmers' pool → 1	8.00 10.00	12.50 16.66	0.60/0.80 to max. 1.35 m	 3.20 m
combined pool → 2	8.00 10.00 12.50 16.66 21.00 25.00	25.00 50.00 25.00 25.00/50.00	with lifting floor: 0.30–1.80 m in swimmers' section: 1.80 m in diving section: min. water depth 3.80 + 4.50 (5.00) m	 4.00 m
swimmers' pool	16.66 21.00 25.00	25.00/50.00 50.00 50.00	 min. 1.80 m	4.00 m
wave pool → 3	12.50 16.66 21.00– 25.00	min. 33.00	initial water depth: 0.00 m (if step, max. 0.30 m) final water depth: according to the use of the pool and type of wave machine	 4.00 m

Pool perimeter; perimeter areas generally at the same level as water	Width (m)
in the main access area to the swimming pool:	3.00
in main entrance area between pool steps and hall wall:	2.50
at the starting blocks:	3.00
at the diving facility:	4.50
(behind the 1 m diving board: free passage min. 1.25 m)	
at the access to the paddling pool	2.00
non-swimmers' pool – steps side:	2.50
non-swimmers' pool – narrow side:	2.00
between diving, swimmers' or combined pool and the non-swimmers' pool or non-swimmer's section of the combined pool:	4.00
between swimmers' pool or swimmers' section of a combined pool and the divers' pool:	3.00
remaining widths for a water area less than 300 m²	min. 1.25
over 300 m²	min. 1.50

ceiling height at pool perimeter:		2.50
lifeguard's room	space requirement: min. 6 m²	2.50
sanitary room	space requirement: min. 8 m²	2.50
equipment room	up to 450 m² water area, min. 15 m²	2.50
	over 450 m² water area, min. 20 m²	2.50
	lounge for competitors:	2.50
	6 swimming lanes = 30 m², 8 = 50 m², 10 = 70 m²	
	teaching and club: 30 up to 60 m²	2.50
spectator facilities	stands: 0.5 seats per 1 m² water area used for sport space required for 1 seat: 0.5 m² including immediate traffic area spectator cloakrooms, space required: 0.025 m² per 1 m² water area used for sport spectator toilets: the toilets in the entrance area (ladies: 1 WC, gents: 1 WC, 1 urinal) are sufficient for 200 spectators. For larger spectator facilities, 1 additional toilet (WC or urinal) for every 100 further spectators plus 1 toilet (WC or urinal), with a ratio of ladies: 2 WCs, gents: 1 WC, 2 urinals.	
workplaces for press and television	Good view of the start and finish (raised position) required: 5–20 places, each place 0.75 × 1.20 m Required: 4–6 places, each place 1.20 m × 1.50 m	
catering (café/restaurant)	Space required per vending machine: 0.5–0.8 m² Seated area: min 50 seats, each seat 1–2 m² supply and subsidiary rooms (additional): for café approx. 60% of seating area, for restaurant approx. 100% of seating area, of which 20–25% for stores and cool room, for empty packaging 15–20%, for kitchen, pantry, office, staff, remaining area. Toilets: min. ladies, 1 WC, gents, 1 WC, 1 urinal.	
services area	Total area for services (without wave water tank, storeroom, sub-station and gas supply room): up to 1 m² per 1 m² planned water area; for larger indoor pools, a reduction of up to 30% is possible.	



St. Moritz channel

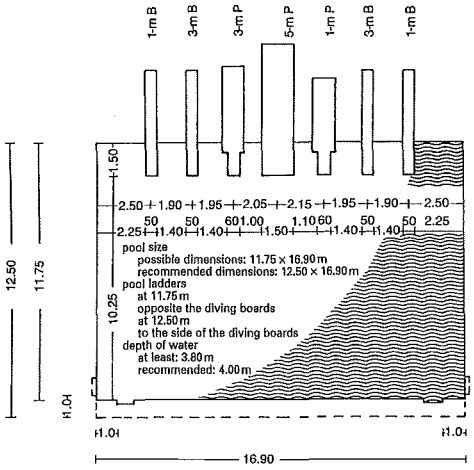


Wiesbaden channel

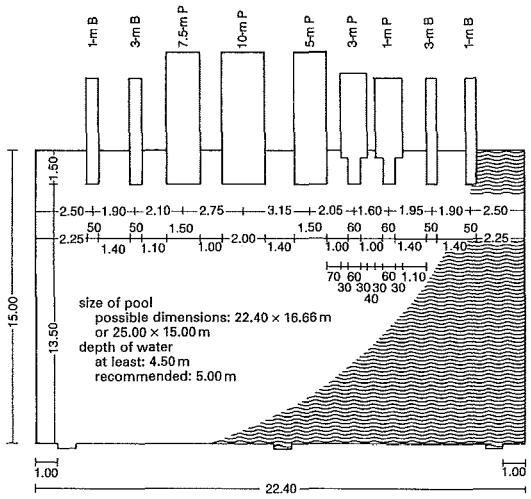
SWIMMING POOLS

Indoor Public Pools

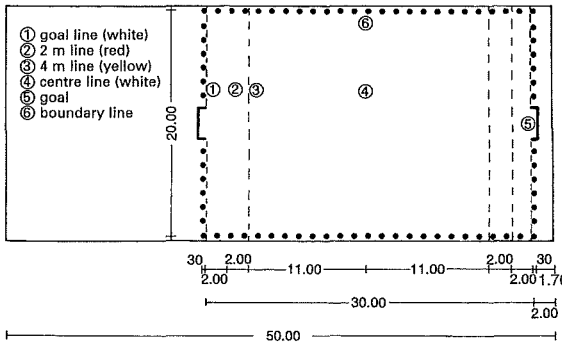
Diving facilities are used for school and competitive sport. Two diving-off points are used: a rigid platform at heights of 1, 3, 5 and 10 m, and a rebounding springboard, made of aluminium, wood or plastic, at heights of 1 and 3 m. The height of the diving positions is measured from the water surface. The climb up to the board or to the platform is up steep steps. All diving facilities are on one side of the pool → ❶ – ❷. **Water temperature:** 24–28 °C. In order for divers to be able to discern the water surface better, water rippling devices or sprinkler jets can be provided.



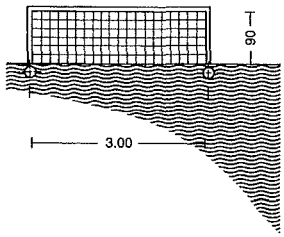
❶ 1–5 m diving facilities (complete). B = board, P = platform



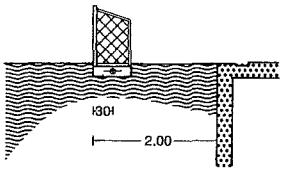
❷ 1–10 m diving facilities (complete). B = board, P = platform



❺ Water polo playing area

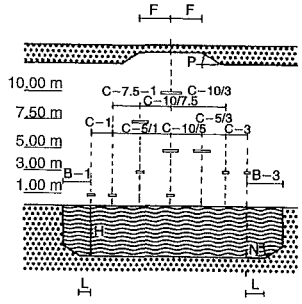


❻ Water polo goal (front view)

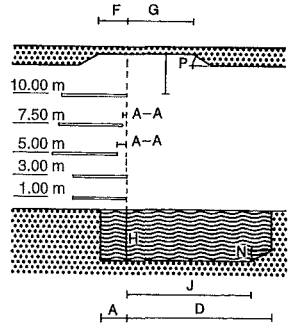


❼ Water polo goal (side view)

Alternative: with a hook-in goal in a 25 m pool, at least 70 cm



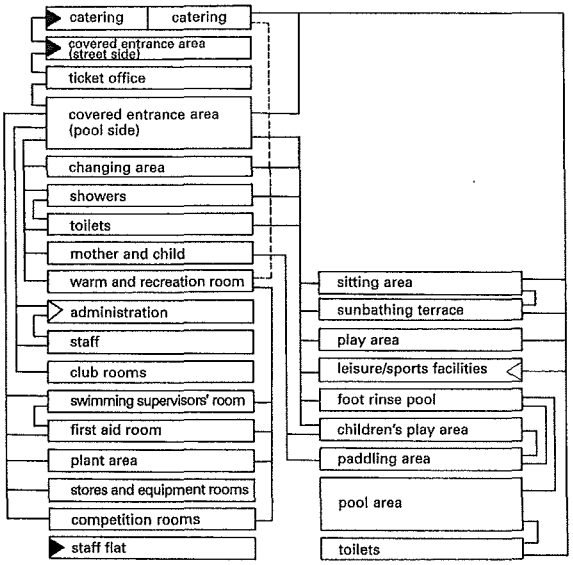
❸ Cross-section



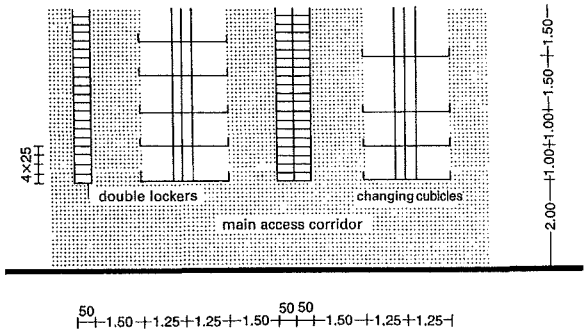
❹ Longitudinal section

	Dimensions of diving facilities	Length/width	1 m board 4.80/0.50	3 m board 4.80/0.50	1 m platform 4.50/0.60	3 m platform 5.00/0.60	5 m platform 6.00/1.50	7.5 m platform 6.00/1.50	10 m platform 6.00/2.00
A	from front edge of board/ platform back to pool side	min. dimension	1.50	1.50	1.50	1.50	1.50	1.50	1.50
A-A	from front edge of uppermost board/platform back to pool sidewall	min. dimension				1.25	1.25	1.25	
B	from centre of board/platform sideways to pool sidewall	min. dimension	2.50	3.50	2.30	2.80	4.25	4.50	5.25
C	from centre to centre	min. dimension	1.90	1.90	—	—	2.10	2.10 or 2.45	3.13 or 2.65
D	from front edge of board/ platform to forward pool sidewall	min. dimension	9.00	10.25	8.00	9.50	10.25	11.00	13.50
E	from top of board/platform to underside of ceiling	min. dimension	5.00	5.00	3.00	3.00	3.00	3.20	3.40
F	space, within which the dimension 'E' is to be complied with backwards and to each side of the centre of the board/platform	min. dimension	2.50	2.50	2.75	2.75	2.75	2.75	2.75
G	space, within which the dimension 'E' is to be complied with from the front edge of the board/platform	min. dimension	5.00	5.00	5.00	5.00	5.00	5.00	6.00
H	water depth under the board/ platform	min. dimension	3.40	3.80	3.40	3.40	3.80	4.10	4.50
J	distance from the front edge of the board/platform forwards	min. dimension	6.00	6.00	5.00	6.00	6.00	8.00	12.00
K	water depth at distance to 'J'	min. dimension	3.30	3.70	3.30	3.30	3.70	4.00	4.25
L	distance sideways of the centre of the board/platform	min. dimension	2.25	3.25	2.05	2.55	3.75	3.75	4.50
M	water depth at a distance from 'L'	min. dimension	3.30	3.70	3.30	3.30	3.70	4.00	4.25

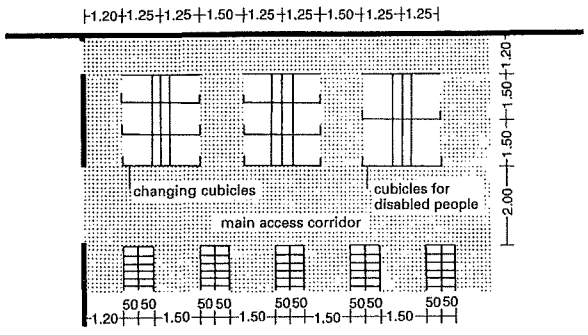
❽ Safety dimensions for diving facilities → ❶ – ❼



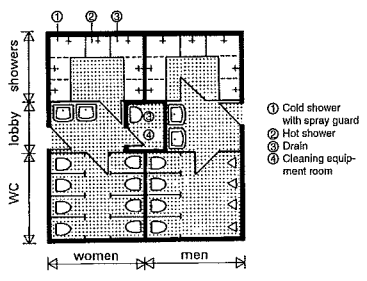
1 Room and area relationship scheme



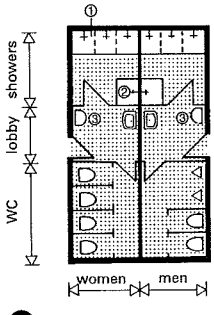
2 Cloakroom unit (scheme)



3 Cloakroom unit (scheme)



4 Sanitary facilities for 2000 m² water area (scheme)



5 Sanitary facilities for 1000 m² water area (scheme)

SWIMMING POOLS

Outdoor Pools

Building plot size: 10–16 m² of the planned water area.

Parking: 1 car and 2 bicycle spaces per 200–300 m² of building plot area.

Space in front of entrance: 150 m² per 1000 m² water area, 50 m² per 1000 m² water area for roofed entrance zones, including cash desk and access control equipment.

Changing area: changing places as cubicles: 0.01 per m² water area, per 1000m² water area min. 10 changing places, of which: 8 changing places as cubicles including 2 cubicles for families and wheelchair users and 2 privacy-screened changing places on the sunbathing lawn. Communal changing rooms: as required, min. 2 communal changing rooms, each with 10.00 m bench length.

Cloakrooms: cloakroom places and lockers for valuables: 0.1 per m² water area, 20 lockers for valuables per 100 cloakroom places.

Sanitary facilities: child–parent area: 15–25 m².

Showers: per 1000 m² water area 3 warm showers for ladies, 3 warm showers for gents, possibly also 1 cold shower per shower room.

Toilets: per 1000 m² water area: 4 WCs for ladies, 2 WCs and 4 urinals for gents, anteroom with washbasin.

Foot disinfection point: according to local regulations. Foot washing and rinsing point (combined): per 1000 m² water area, 4 taps.

Covered area for weather protection: per 1000 m² water area, 100 m² covered area.

Warm lounge room: per 1000 guideline units 30–70 m², min. 50 m².

Staff rooms: up to 1500 m² water area, up to 10 m²; over 1500 m² water area, up to 30 m².

Lifeguard's room: approx. 10 m².

First aid room: approx. 8 m², if combined with lifeguard's room and sanitary facilities, approx. 14 m².

Store and equipment room: up to 1000 m² water area, min. 30 m² (recommended: 50 m²); over 1000 m² water area, min. 50 m² (recommended 80 m²).

Pool area

Paddling pool: water area: 80–200 m², water depth: 0.00–0.60 m, division into a number of pools of differing depths is ideal.

Non-swimmers' pool: water area: 600–1500 m², water depth: 0.50/0.60–1.35 m, possibly divided into a number of pools of differing depths.

Swimming pool: water area: 313–1050 m², water depth: > 1.80 m, pool size according to number of swimming lanes.

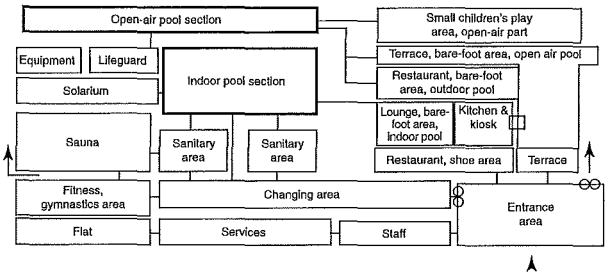
Swimming lanes	Pool width	Pool length
5	12.50 m	25.00 m
6	16.66 m	25.00 m
6	16.66 m	50.00 m
8	21.00 m	50.00 m
10	25.00 m	50.00 m

Wave pool: pool width: 12.50 m, 16.66 m, 21.00 m, 25.00 m, pool length: 50.00 m, min. 33.00 m, initial water depth: 0.00 m, final water depth according to pool use and type of wave machine.

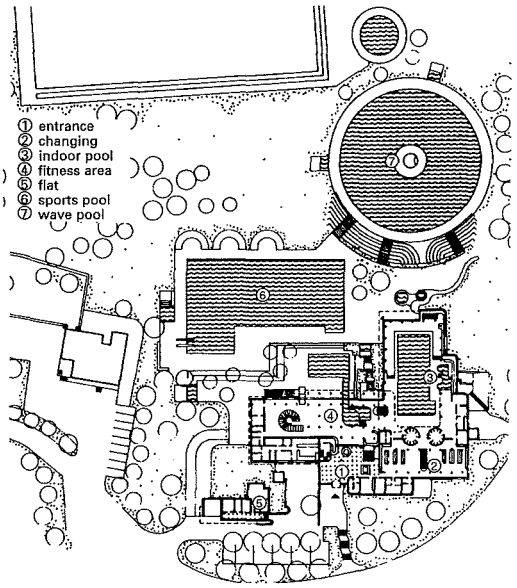
Pool perimeter: min. width 2.50 m. Near the access points and the starting blocks, 3.00 m; near the pool steps to the non-swimmers' pool 3.00 m, near the diving facility 5.00 m.

Open areas: approx. 60% of the building plot area, divided into sunbathing, leisure sport and children's play areas. Ratio sunbathing area: sport area = 2:1 to 3:1.

Children's play area: dry area: sandpit 100–300 m², play area 300–700 m². Wet area: water play area 100–500 m².



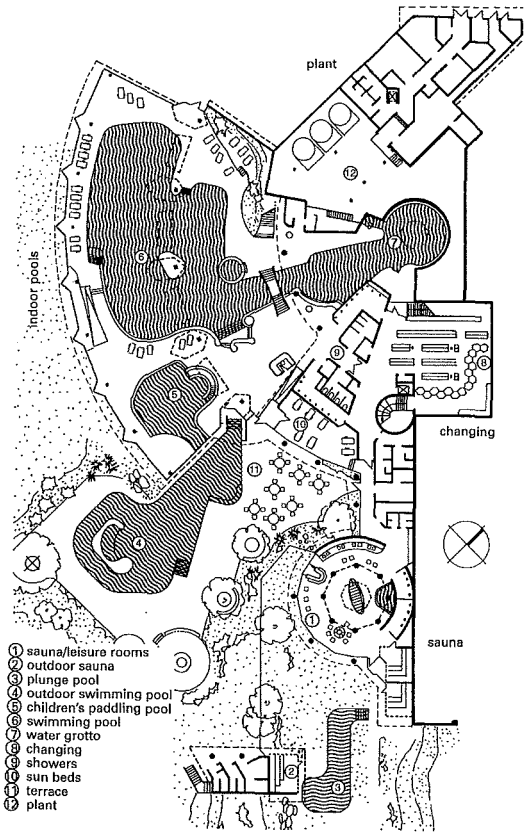
1 Room and functional scheme



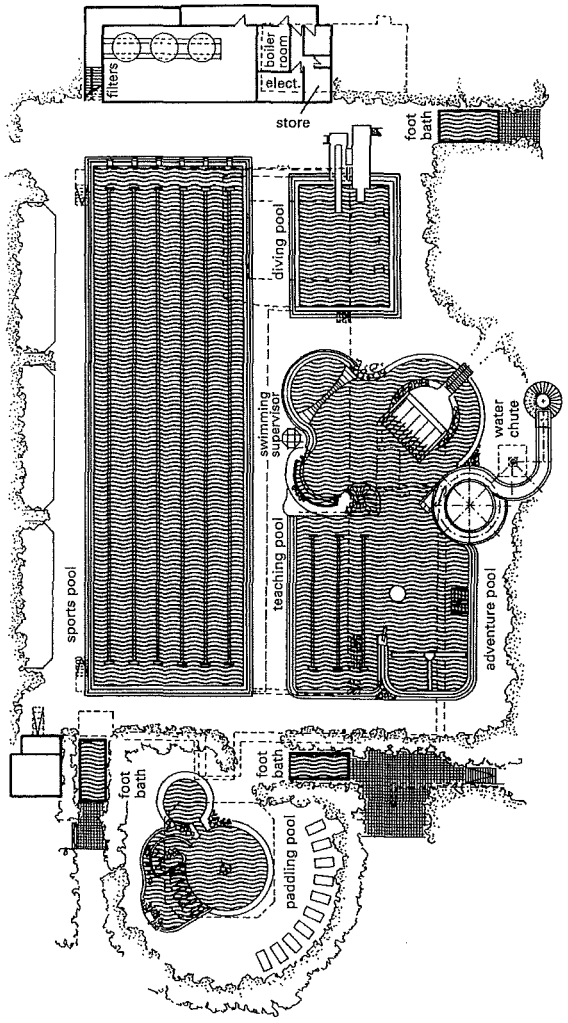
2 The Wellenberg, Oberammergau Arch.: P. Seifert

Combinations of indoor and outdoor swimming pools enable, according to the type of operation, almost complete spatial, functional and operational combination of the individual facilities' components. At the same time, they also offer more flexible opportunities for use and thus possess a higher leisure value than outdoor or indoor pools alone. The differing needs at different times of year require different areas of water indoors and outdoors. Operation can be categorised into summertime, wintertime and in-between (pre-season and after-season).

The following types of operation can be considered: simultaneous use of the inside and outside water areas with common opening times, unlimited bathing time and unitary entrance price; separate use of the indoor and outdoor water areas with different opening times, partially unlimited opening times (outdoors) and different prices; seasonal use of only one part, e.g. by mothballing one part. Combinations of indoor and outdoor swimming pools can sometimes also be achieved by extending the facilities at existing pools, adding an indoor or outdoor section. If the indoor and outdoor parts of a new project are not to be opened in one construction phase, then the design of the entire facility should be undertaken, including technical specialist design work. This can avoid double expenditure. The first construction phase should generally be the indoor swimming pool.



3 Leisure pool, Heveney Arch.: Aichele; Fiedler; Heller



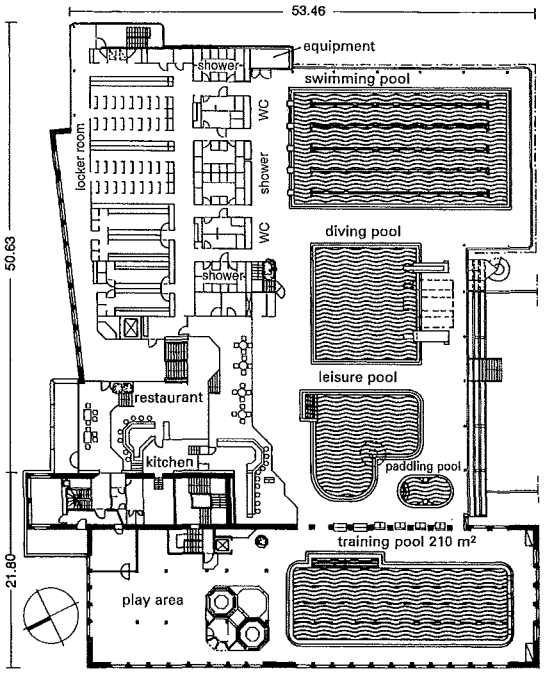
4 Outdoor pool, Bad Driburg Arch.: Geller + Müller

The building plot size should be in line with the requirements for an outdoor pool. With a plot requirement <10,000 m² for the indoor element, a supplement of 5.00 m² per m² of water area should be added for the outdoor. Otherwise, the design recommendations for indoor or outdoor pools apply.

The pool area of the outdoor pool should ideally be connected to the pool area of the indoor pool. This ensures better utilisation between seasons, central supervision and a favourable technical combination. The lounge area with catering should have a view of both pools if possible.

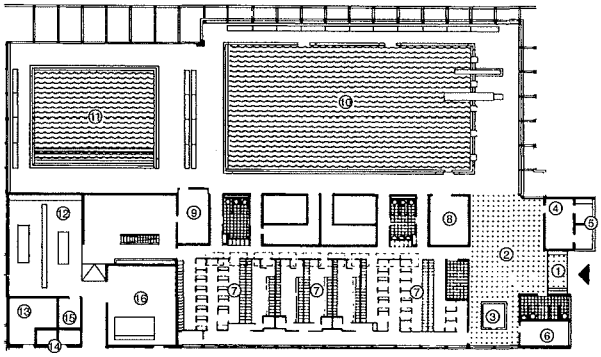
Access to the outdoor pool is normally through the entrance hall of the indoor pool, but at peak times this can be supplemented by the covered entrance zone. The cash desk and access control area should serve both parts if possible.

A close link between the pool areas in the indoor and the outdoor facilities enables flexible use. The connection between the two, preferably to the non-swimmers' section of the outdoor pool, can be through a swimming channel (with access in the indoor pool) or a closed corridor. The intention is that the bathers can reach an outdoor pool from the indoor pool without contact with cold outside air.

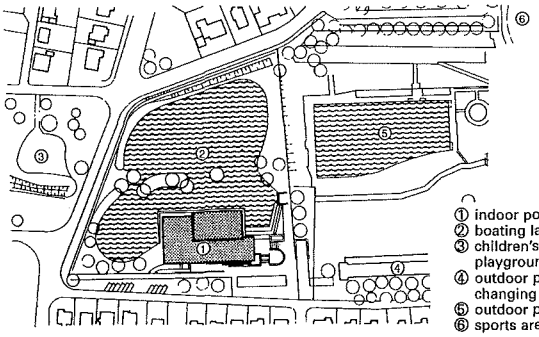


1 City pool, Trier — Arch.: Müller, Karnaiz & Bock

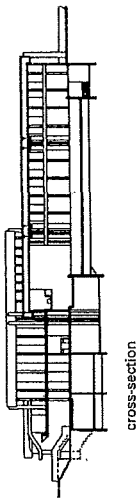
① draught lobby
② entrance hall
③ ticket office
④ staff
⑤ staff changing
⑥ office
⑦ changing
⑧ equipment
⑨ swimming supervisor
⑩ swimming pool
⑪ learners' pool
⑫ plant, filters
⑬ transformer room
⑭ chlorine room
⑮ battery room
⑯ heating



2 Ground floor → 3



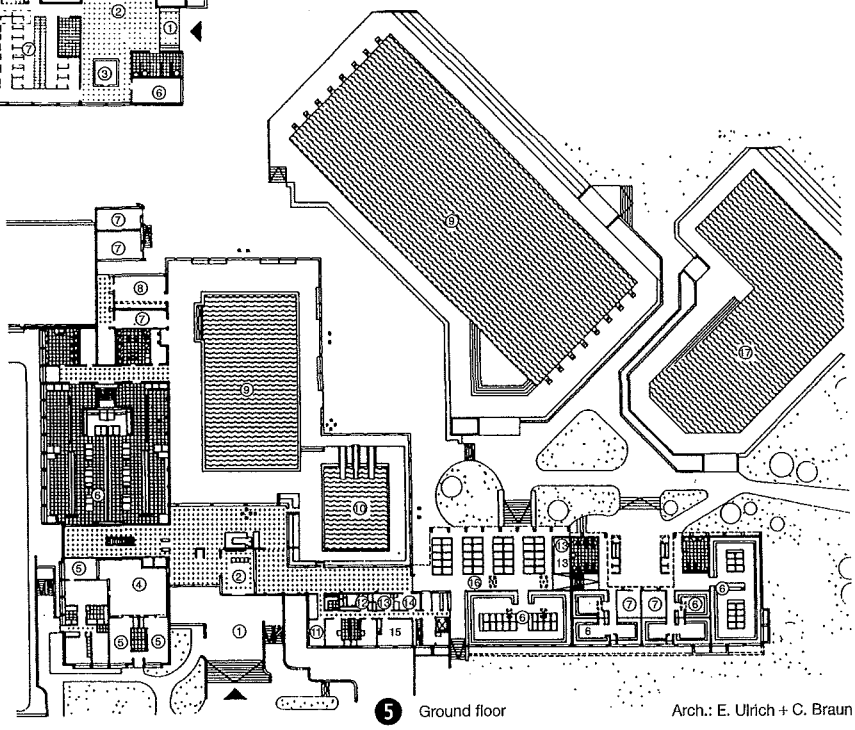
3 Indoor swimming pool, Stuttgart → 2 — Arch.: J. Welz



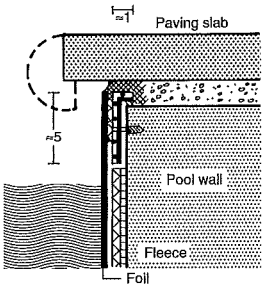
ground floor → 5

① elevated entrance
② draught lobby
③ ticket office
④ atrium
⑤ flat
⑥ changing
⑦ equipment
⑧ swimming club
⑨ swimming pool
⑩ diving pool
⑪ office
⑫ teacher
⑬ swimming supervisor
⑭ first aid
⑮ leisure room
⑯ family cubicles
⑰ non-swimmers

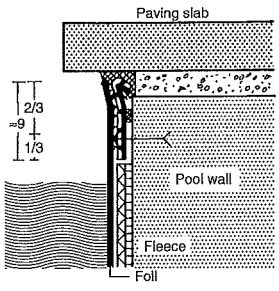
4 Indoor and outdoor pool, Zollikon → 5



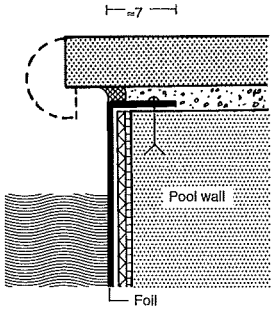
5 Ground floor — Arch.: E. Ulrich + C. Braun



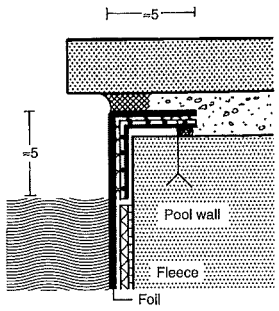
❶ Edge connection/foil lined pool with bonded sheet metal



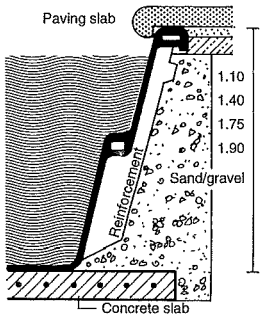
❷ Variant → ❶



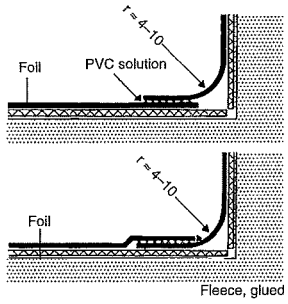
❸ Foil fixed to pool wall



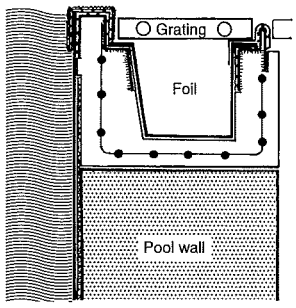
❹ Edge connection with angle of bonded sheet metal



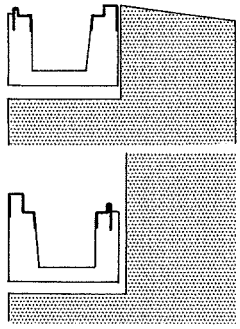
❺ Pre-fabricated pool



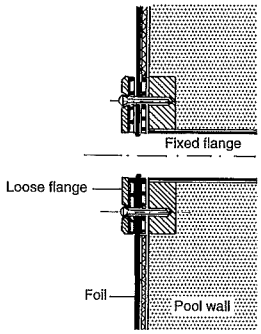
❻ Connections at floor/sidewall with rounded corner



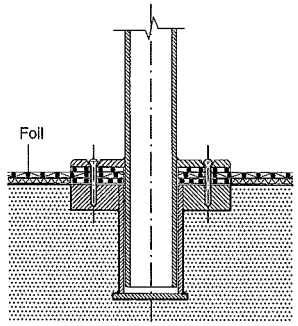
❼ Pre-cast concrete gutter/foil liner



❽ Variant → ❻



❾ Fixed flange connection



❿ Fixed flange with anchor sleeve

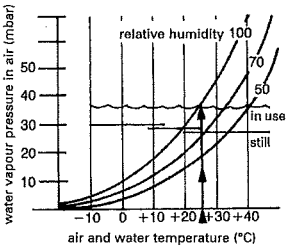
Construction details

The use of foils for the lining of swimming pools saves the normal expense of waterproof sub-structure. The foil in areas around stairs, standing steps and children's paddling pools should have an embossed and structured surface for safety reasons. At penetrations, fixed flange connections are helpful → ❾ – ❿. Possible condensation on the side away from the water should be considered, and secondary drainage or relief drillings should be provided under the waterproofing layer. In order to empty the pool, the floor is constructed with a gradient of 5% or max. 10%. In order to securely connect the foil, use bonded sheet metal profiles → ❶ – ❹. Also possible are pre-fabricated pools in one piece as a shell structure, or segmental pools.

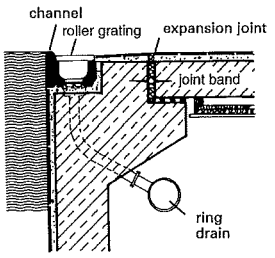
	Relative air humidity				
	50%	60%			70%
	Air temperature				
	28°C	26°C	28°C	30°C	28°C
24°C R	21	13	0	– [1]	0
M	219	193	143	– [1]	67
26°C R	48	53	21	2	0
M	294	269	218	163	143
28°C R	96	104	66	31	36
M	378	353	302	247	227
30°C R	157	145	123	81	89
M	471	446	395	339	320

[1] temperature difference 4 K water/air cannot be held in the long term

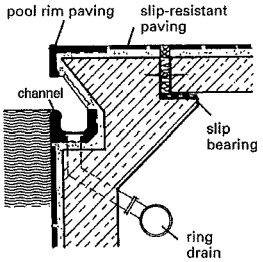
⓫ Specific quantity of evaporation in an indoor pool (g/m³h): out of operation (R) and max. use (M) (Kappler → refs)



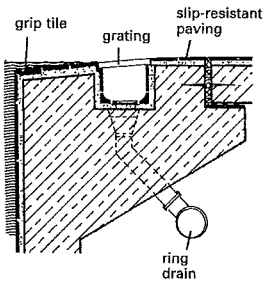
⓬ Evaporation limit for an indoor pool: upper line, in use; lower line, out of operation



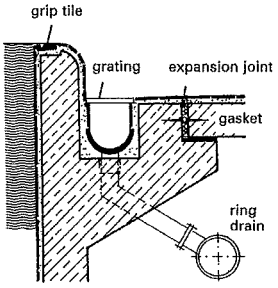
⓭ 'Zürich' pool edge overflow system



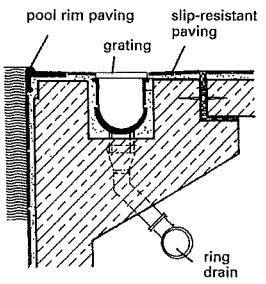
⓮ 'Wiesbaden' overflow channel system



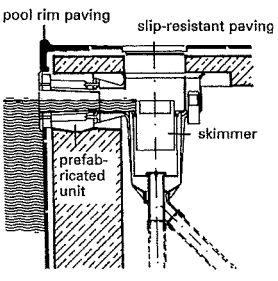
⓯ Finnish channel



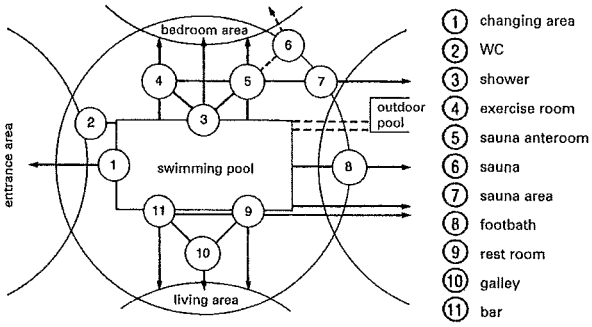
⓰ 'St. Moritz' overflow channel system



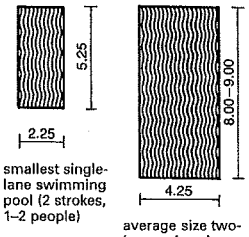
⓱ Overflow channel with pool edge kerbstone and drainage channel



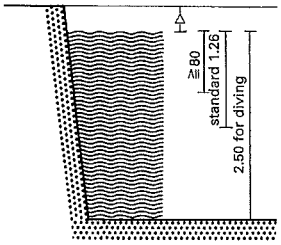
⓲ Surface skimmer



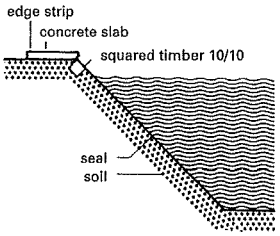
❶ Related elements of the indoor pool of a detached house. A flat part of the swimming hall can also be the living room.



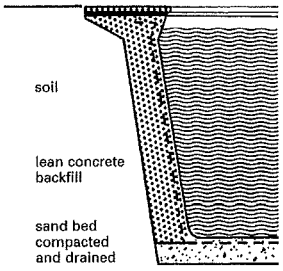
❷ Pool sizes



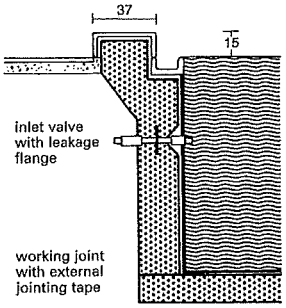
❸ Pool depth



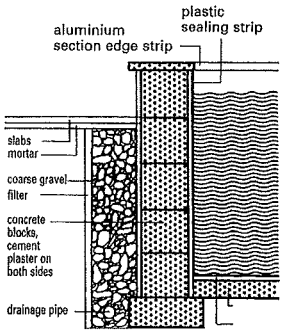
❹ Sloping pool with foil; edge formed by timber beam



❺ Single-skin prefabricated polyester pool



❻ Reinforced concrete pool: simple version with Wiesbaden channel



❼ Masonry pool with drainage

Water	Season			Additional months	
temp.	4 Months	5 Months	6 Months	5th Month	6th Month
22°C	1.25/6.5	1.33/7.2	1.55/7.8	1.65/7.2	2.65/7.8
23°C	1.50/7.2	1.70/7.9	2.00/8.5	2.50/7.9	3.50/8.5
24°C	2.08/7.9	2.26/8.6	2.66/9.2	2.98/8.6	4.66/9.2
25°C	2.60/8.5	2.80/9.3	3.20/9.8	3.60/9.5	5.25/9.8
26°C	3.50/9.2	3.75/10.0	4.00/10.5	4.75/10.0	5.25/10.5

❽ Heat loss of an outdoor pool (average/maximum) in kWh/m²d according to measurements by energy company RWE. Special influences are not considered, e.g. considerable heat loss of public pools (hotel pool etc.) through the use of heated pool water for filter back-flushing (up to 1.5 kW/m²d or 1300 kcal/m²d).

Location
Protected from wind → ❶, near the bedroom (for use on cool days), visible from the kitchen (keep an eye on children) and living room (scenery effect), i.e. in view. No deciduous trees or bushes next to the pool (falling leaves). Prevent grass etc. falling in at the sides, possibly with a raised edge (design question).

Size
Lane width 2.25 m, stroke length approx. 1.50 m, plus body length: 4 strokes = 8 m length. Water depth: chin height for the smallest adult, not the children! Difference between pool depth/water depth → ❸, depends on the type of extractor system.

Shape
As simple as possible due to cost and water management (see below), rectangular, always with ladder or step recess.

Types of pool
Normal foil pool (foil = waterproof surface) on masonry-bearing construction → ❼, concrete, steel (also above ground) or sunk into ground → ❹.

Polyester pools, seldom locally produced, mostly with prefabricated elements, are generally not self-supporting. Lean concrete backfilling is necessary → ❺.

Watertight concrete pool → ❻ (two-sided in situ concrete, shotcrete with formwork for one side, pre-cast concrete elements); surface mostly ceramic or glass mosaic, occasionally paint (chlorine rubber, cement paint).

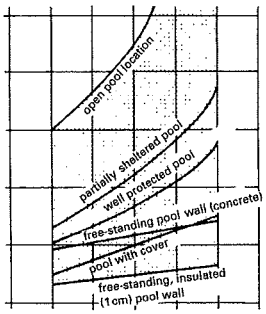
Water cleaning
A recirculation system is usual today, generally providing flat water flow with the good surface cleaning effect of a skimmer or a channel.

Filter types
Gravel (deep filter, sometimes with cleaning air injection), diatomite (surface filter), plastic foam. Algae is combated with chlorine, chlorine-free algae agent, or copper sulphate.

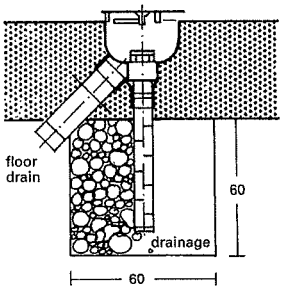
Heating
With counter-current apparatus or through-flow heater in the heating boiler – mind the regulations! This prolongs the swimming season considerably at relatively low cost →❽ – ❾.

Protection of children
Can be through fencing, covering the pool or self-activating alarm device (reacts to waves).

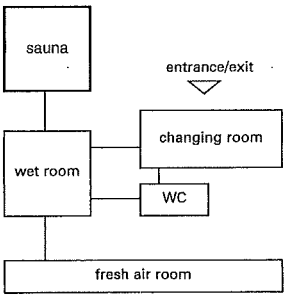
Frost protection
For rigid pools with inserted edge beam, heating or overflow kept frost-free. A pool should not be emptied in winter (sloping edge of pool).



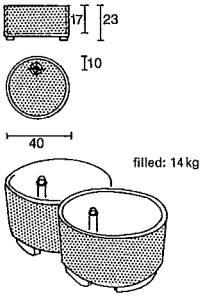
❾ Heat loss from a pool surface or the free-standing poolside wall for a 5-month season (average values)



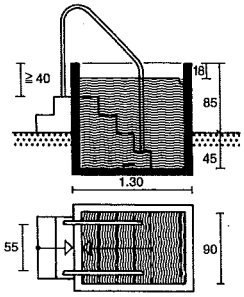
❿ Floor gully with groundwater pressure balance



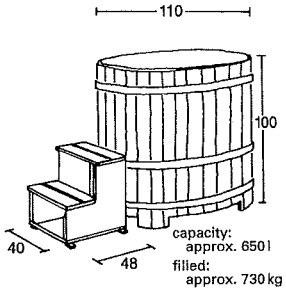
❶ Functional scheme of a private sauna



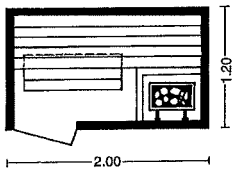
❷ Warm footbath



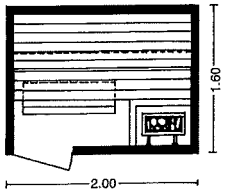
❸ Plunge pool



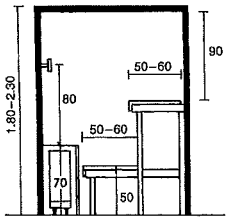
❹ Wooden plunge tub



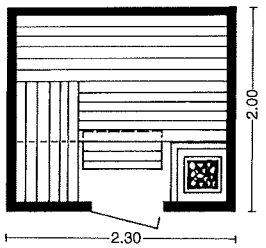
❺ Sauna cabin: one person lying or two sitting



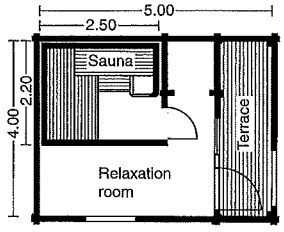
❻ Sauna cabin: two people lying or three sitting



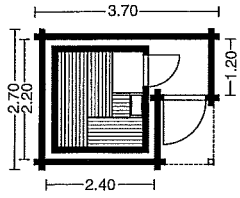
❼ Cross-section



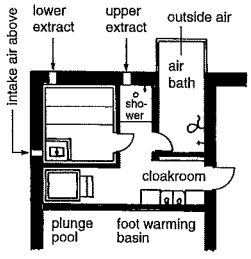
❽ Sauna cabin: three people lying or five sitting



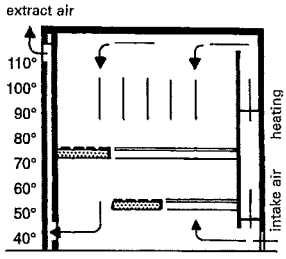
❾ Sauna constructed as log cabin



❿ Sauna cabin constructed as log cabin



⓫ House sauna



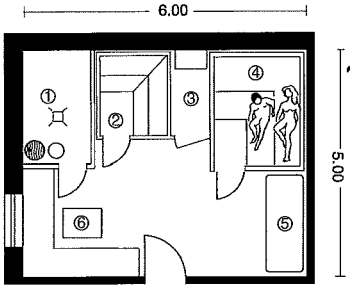
⓬ Cross-section of sauna with indirect heating (Bemberg)

In contrast to the separated features of a commercially operated sauna → p. 373 f., the functions of a private sauna can all be integrated into one room, e.g. changing and relaxation (can also take place in the house) or pre-cleaning and cooling (can take place in the same room with the same sanitary facilities).

Free-standing **sauna cabins** or facilities (e.g. in the garden) are normally constructed of spruce in log cabin style, and are either self-built or bought pre-fabricated. The log cabins are available in various versions, either as sauna cabins → ⓾ or also with shower and changing or relaxation room → ❾. There are also sauna cabins available as prefabricated or kit elements for installation in existing rooms → ⓭ + ⓯.

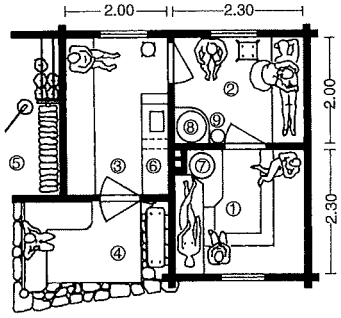
Sauna stove: Sauna cabins for installation usually have electric stoves (which require a three-phase supply above a certain size), while log cabin types mostly have solid fuel stoves (which require a chimney).
Plunge pool → ❸ – ❹ max. depth 1.20 m.
An important part of a proper sauna, a (warm) **footbath** → ❷ with a seat are required.
Room temperatures: changing room 20–22°C, wash room ≧24–26°C, cooling room ≦18–20°C, rest room 20–22°C, massage room 20–22°C.
Humidity: 100°C: 2–5% rel. humidity, 80°C: 3–10% rel. humidity, 70°C: 5–15% rel. humidity, 60°C: 8–28% rel. humidity.

① Shower
② Steam bath
③ Equipment
④ Sauna
⑤ Sun bench
⑥ Sitting & relaxation corner



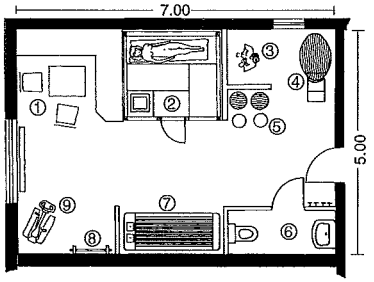
⓭ Sauna (installed, e.g. in cellar), 30 m², 4–6 people

① Sauna cabin
② Massage & washing room
③ Changing room
④ Veranda
⑤ Wood pile
⑥ Cubboard
⑦ Heating oven
⑧ Water kettle
⑨ Water tub

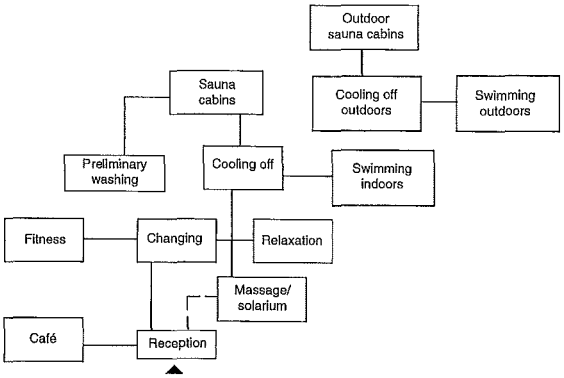


⓮ Sauna

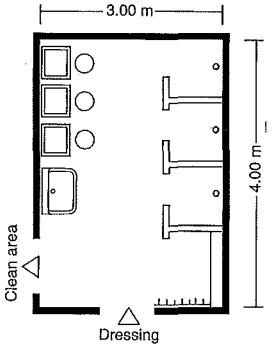
① Sitting & relaxing corner
② Sauna cabin
③ Shower
④ Plunge pool
⑤ Footbath
⑥ WC
⑦ Sun bench
⑧ Wall bars
⑨ Ergometer



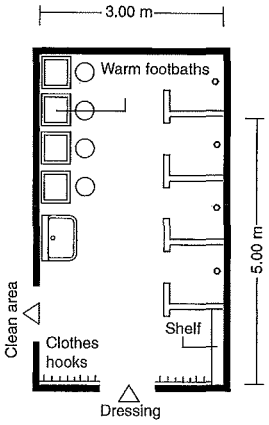
⓯ Sauna, 35 m², 4–6 people, sauna cabin as built-in element



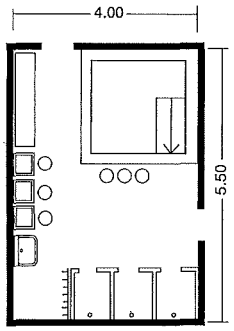
❶ Functional scheme of a sauna



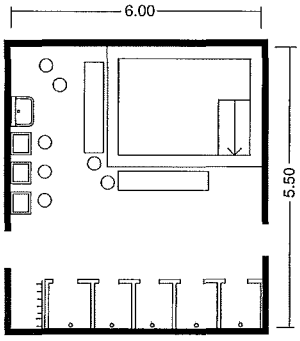
❷ Wash room of size III, approx. 12.00 m²



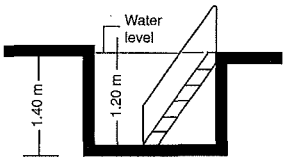
❸ Wash room of size IV, approx. 15.00 m²



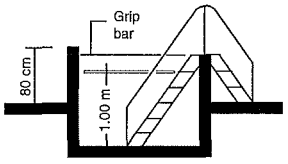
❹ Cooling room of size III, approx. 22 m²



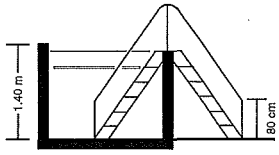
❺ Cooling room of size IV, approx. 33 m²



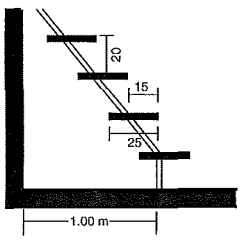
❻ Plunge pool, sunken



❼ Plunge pool, half-sunken



❽ Plunge pool, free-standing



❾ Steps in plunge pool

Spa is the general term for health and wellness establishments, which should generally include: sauna facility, massage and solarium, relaxation, fitness and condition training (including swimming → Indoor and outdoor swimming pools).

A commercially operated **sauna** (size III–IV → ❾) will include:

Changing room, shower room with **washing facilities, sauna cabins, rest/relaxation room** and **subsidiary rooms** (staff room, reception, cash desk, sanitary facilities for visitors and staff). In public saunas, separate rooms are provided for changing, preliminary washing and toilets; for staff and visitors' toilets, the relevant building regulations apply. Access to swimming areas, food/drink providers and fitness areas is increasingly being offered in spa and wellness establishments.

The **wash room** is used for washing with warm water before entering the sauna → ❷ – ❸.

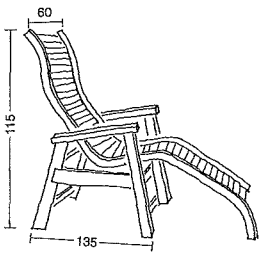
The **cooling room** is used for cooling off between visits to the sauna using cold air or cold water in, for example, plunge pools, pouring water, showers and footbaths → ❹ – ❾.

Size	No. sauna places	Type of use
I	2–4	very small or family sauna
II	4–5	family sauna
III	6–10	commercially operated sauna
IV	11–15	large commercially operated sauna

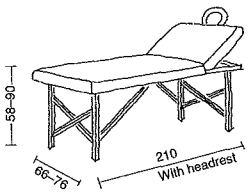
Room type	Size	Average room size (m²)	Places	Usable area (m²)
sauna	I	1.0–4.0	2–4	
	II	7.0–11.0	4–5	
	III	12.0–17.0	6–10	
	IV	17.5–21.0	11–15	
cooling room	II	16.0	up to 12	16.0
	III	22.0	up to 12	22.0
	IV	30.5	up to 17	30.5
washing room	II	9.0	up to 8	9.00
	III	12.0	up to 12	12.00
	IV	17.0	up to 17	17.00
changing room	II	16.0	up to 20	12.00
	III	24.0	up to 30	18.00
	IV	34.0	up to 45	20.00
rest room	II	13.2	2–3	10.00
	III	18.0	6	20.00
	IV	27.0	8	30.00

Capacity parameter	Size			
	I	II	III	IV
no. sauna places	2–3	4–5	6–10	11–15
usable area (m²)	1.7–2.2	2.4–4.0	5.0–10.0	8–13
cabin size (m/place)	1.7–2.3	1.2–1.6	2.0–2.4	1.8–2.0
ceiling height (m)	2.00	2.10	2.40	2.40
in the smallest sauna with 2 seating levels: ceiling height: 1.90 m, min. 1.80 m; clear height above the upper seat: 1.00–1.10 m				

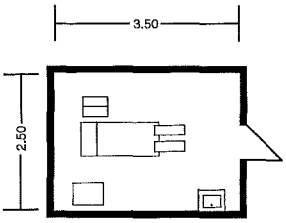
❿ Approximate room and space requirements for various sizes of sauna (Höckert → refs)



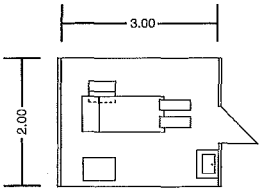
1 Ergonomic couch in the sitting position in relaxation room. Length in lying position: 1.70–1.90 m



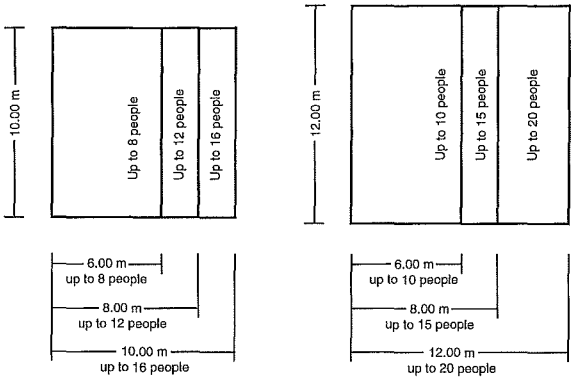
2 Massage couch with head rest



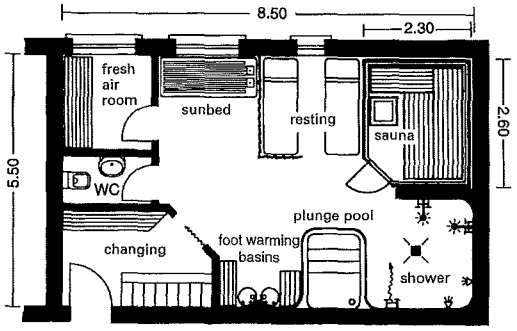
3 Massage room 8.75 m², surrounded by solid walls



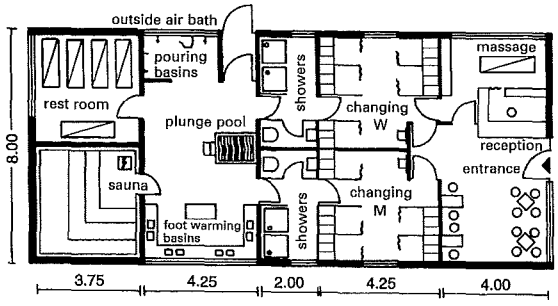
4 Massage compartment 6.00 m², separated by curtains



5 Pool sizes for swimming and exercise pools in sauna area (usable capacity)



6 Hotel sauna 5.50 × 8.50 m

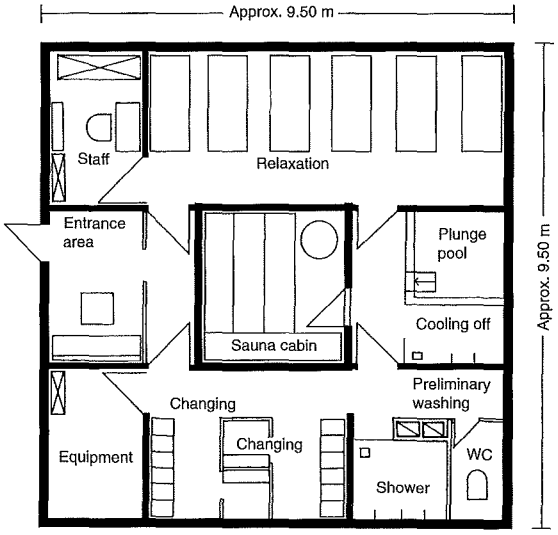


7 Sauna for approx. 30 people

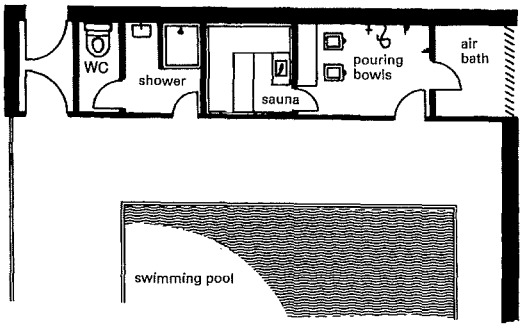
Rest room
Provides relaxation between or after visits to the sauna. It should be well ventilated and have visual contact with the outside and a low noise level. The design and furnishing should be suitable for rest and relaxation.
Solarium: an area of approx. 0.80 × 2.00 m is required per lying place. The side aisle width is 0.40 m.
Pool types and sizes → ❺:
Whirlpool: for relaxation and recovery. Max. water depth: 1.0 m.
Exercise pool: for relaxation, rehabilitation, water gymnastics and health care, max. water depth: 1.35 m, water area 25–60 m²:
- **salt-water pool:** water with a salt content of min. 5.5 g sodium and 8.5 g chloride per litre.
- **mineral pool:** water with a mineral content of min. 1 g per litre.
- **thermal pool:** water with a natural temperature >20 °C. Because this pool is not for swimming, it can, according to use, be designed in almost any shape.

Size of sauna cabin (m²)	Air supply opening (cm²)	Air extraction opening (cm²)
5	100	70
10	150	105
15	200	140
20	250	175

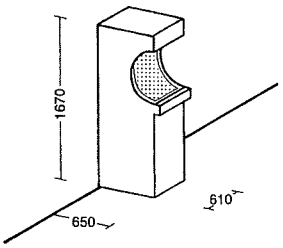
8 Size of ventilation openings in relationship to floor area of sauna cabin (Höckert → refs)



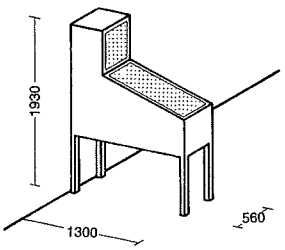
9 Sauna facility with washing and cooling rooms for about 12 people, approx. 90 m²



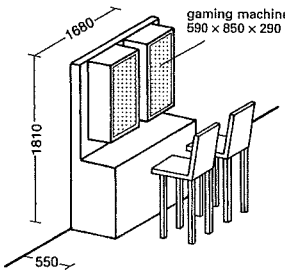
10 Sauna and indoor swimming pool



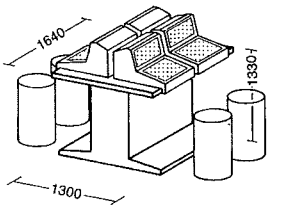
1 Games console



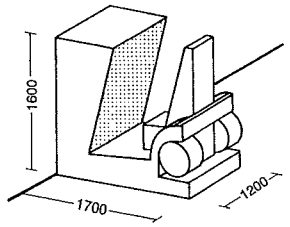
2 Flipper



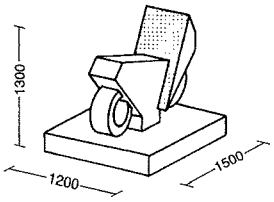
3 Standing slot machines



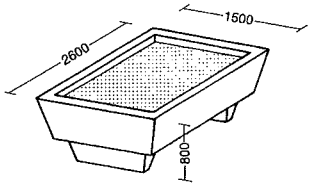
4 Card game machine



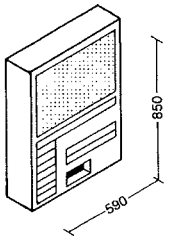
5 Driving simulator



6 Bike simulator



7 Pool table



8 Slot machine

The provision of gambling machines, often called fruit machines or slot machines, is controlled by gambling regulations. According to these, a gambling machine offering the possibility of winning money or goods may be made available in amusement arcades or similar enterprises.

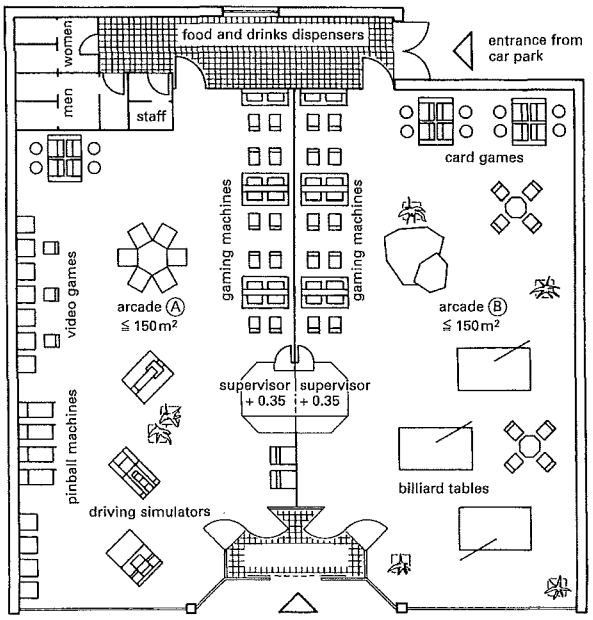
On a floor area of 15 m^2, only one gambling machine to win money or goods may be positioned. The total number may not exceed 10 machines → ⑨. In the calculation of floor area, storerooms, corridors, toilets, anterooms and stairs are not considered.

In addition to building regulations, planning regulations also have to be borne in mind for the building of amusement arcades. Amusement arcades are permissible as places of entertainment in urban planning zones. In exceptional cases, they can be approved in other zones, in which commercial businesses which could cause a nuisance are not allowed. Automated entertainment machines, which offer prizes as goods, can also be made available in amusement arcades, but other games only if their winnings are paid in cash.

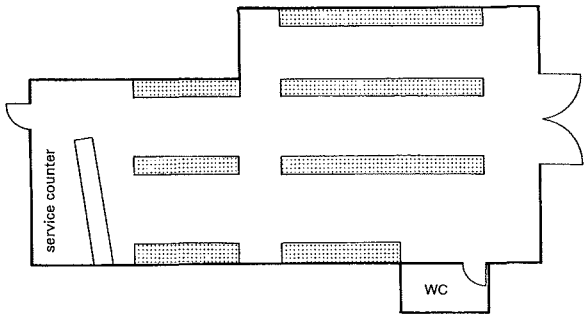
Games may not be organised in amusement arcades without permission. Neighbouring amusement arcades can share common toilet facilities → ⑨.

The 'Pachinko' amusement arcades usual in Japan → ⑩ – ⑪ are not permissible in Germany. Balls won in these games can be exchanged for goods.

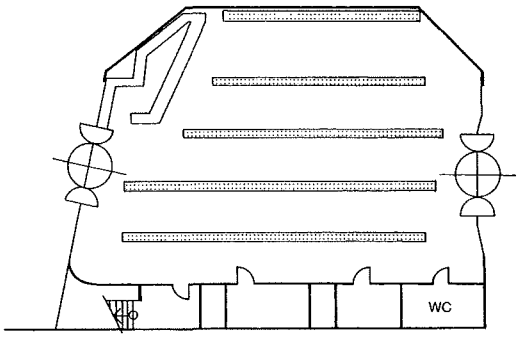
In the UK, gaming by means of machines is restricted and is governed by the Gaming Act 1968.



9 Plan of amusement arcade



10 Japanese 'Pachinko' amusement arcade



11 Japanese 'Pachinko' amusement arcade