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European inland waterway network:
Guidelines for Waterway Signs and Marking
(Resolution No. 59, revised)

Instruction on the installation of signs and markings on the Danube

Transmitted by the Danube Commission

Mandate

1. This document is submitted in line with cluster 5: Inland Waterway Transport, paragraph 5.1 of the programme of work 2014-2015 (ECE/TRANS/2014/23) adopted by the Inland Transport Committee on 27 February 2014.

2. The document reproduces below the "Instruction on the installation of signs and markings on the Danube" adopted at the eighty-fourth session of the Danube Commission on 9 June 2015. The Danube Commission based this document on the instructions in force and UNECE Resolution No. 59. Initially, it had been planned to harmonize the two documents, but following a significant volume of feedback from the member countries of the Danube Commission, a slightly different document was ultimately drafted, which reflects the standards in force and current knowledge on this issue in the member countries. The Danube Commission proposes using this document as a basis for a possible amendment or updating of Resolution No. 59.

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Annex

Instruction on the installation of signs and markings on the Danube

Introduction

The Instruction on the installation of signs and markings on the Danube was adopted by decision of the forty-ninth session of the Danube Commission (document CD/SES 49/24 of 23 April 1991).

The Instruction was amended by decision of the sixty-sixth session (document CD/SES 66/22 of 8 May 2006) and the eighty-fourth session of the Danube Commission (document CD/SES 84/7 of 9 June 2015).

It is recommended that the Danube countries and special river administrations follow the indications of the respective sections of this Instruction when manufacturing and installing signs on their sectors of the Danube River.

1. General

1.1 In terms of the objectives pursued, the marking of the Danube comprises two categories of signs:

- Signs used to regulate navigation on the waterway, set out in Annex 7 to the Basic Provisions relating to Navigation on the Danube (DFND); and
- Signs and signals on the water and bank marks marking the sides of the fairway and navigational hazards, set out in Annex 8 to DFND.

1.2 The signs set out in Annex 7 to DFND include prohibitory, mandatory, restrictive, recommendatory or informative signs and auxiliary signs.

1.3 In accordance with article 5.01 of DFND, vessels' crew members shall obey the requirements and take account of the recommendations or indications brought to their attention by these signs.

1.4 The signs on the water and bank marks of Annex 8 of DFND are used to indicate the limits, direction and depth of the fairway and, in addition, are used to mark obstacles and structures protruding into the fairway or in its vicinity.

1.5 The number of bank marks and signs and signals on the water and the plan for their on-site location shall meet the requirements of navigational safety.

1.6 The choice of the mark and the establishment of their number depend on the local characteristics of the waterway and the function of the mark. Their installation shall be effected in such a way as to ensure visibility from one to the next.

1.7 The luminous intensity of lights is established by the competent authorities of the respective countries in terms of local navigational conditions. In classifying the luminous intensity, it is recommended to use the classification of luminous intensity in Annex 2 to this Instruction, which also includes calculations for luminous range.

1.8 In principle, the colours of lights should be in keeping with the recommendations of the International Commission on Illumination ("Colours of light signals", in CIE publication S 004/E-2001, class A. The accepted ranges appear in Annex 2 of this Instruction.

1.9 The marks shall be installed by the competent authorities of the Danube countries and by the special river administrations which:

(a) Regularly observe the state of the bed of the river and the changes taking place in it and, on the basis of the results of these observations correct the positioning of the signs and marks and, where necessary, add to them so that they will indicate the fairway dimensions;

(b) Regularly measure the depth and the width of the marked fairway and provide boatmasters with the necessary information concerning minimum channel depths and widths and the river level regime;

(c) Establish the plan for the installation of signs and marks in their respective sectors and establish the type and number of signs and signals on the water and bank marks to be used, in terms of the requirements of navigational safety and local conditions;

(d) Ensure as far as possible the uninterrupted operation of all signs and signals on the water and bank marks;

(e) Inform boatmasters in good time of the date of the installation and removal of signs and signals, of all alterations of importance to navigation to their number, type, positioning and lighting, and the rules they establish permitting the passage of vessels in restricted sections where meeting and passing are prohibited.

2. Requirements to be met by signs and marks and the plan for their installation

2.1 Marking shall be in operation continuously (by day and by night) all along the navigable section of the river, and, as far as possible, as from when the waterway is free from ice until the ice appears; it shall be corrected as changes occur in the level and in the fairway.

In accordance with the state of the fairway, the marking shall be positioned in such a way that the vessels navigating downstream can use the part of the river with the high current speed and the vessels navigating upstream can use the part of the river with the low current speed.

2.2 During periods of high water and icing, the regular marking on the water that is removed to preserve it from possible damage shall be replaced, as far as possible, by marker posts and spars, the topmarks and colours of which shall correspond to those adopted for the respective side of the fairway.

2.3 Signs and signals on the water shall be installed so as to ensure the safety of vessels on the fairway.

2.4 Buoys shall be unsinkable and shall remain unsinkable in all storms, and their main body shall therefore be watertight; they shall not only float but also be stable, i.e. conserve a vertical position as far as possible and not be tipped too much by waves and wind.

2.5 The basic condition which the plan for the installation of the signs and marks shall meet is to ensure the safety of the vessels and the continuity of traffic, by day and by night, throughout the sailing season and to give boatmasters clear and unambiguous indications concerning the direction and the limits of the fairway.

2.6 The plan for the installation of the signs and marks shall be prepared in such a way as to permit a rational combination of bank marks and signs and signals on the water. When the plan is drawn up, it should be based on the conditions of navigation, and specific hydrographic and hydrometeorological conditions, and also on the need to

ensure safety and navigation of all river vessels and, where necessary, of seagoing vessels.

2.7 Bank marks serve to guide boatmasters and to indicate the direction of the fairway. Signs and signals on the water supplement bank marks in sectors where, in order to ensure the safety of navigation, it is essential to indicate not only the direction of the fairway but also its limits, and to mark places where there are obstacles.

2.8 In preparing the plan for the installation of signs and marking, the following requirements should be taken into account:

(a) Only the signs set out in Annexes 7 and 8 to DFND are to be used to mark the fairway and regulate navigation; in exceptional cases special additional bank marks may also be used, provided, however, that the marks are not in contradiction with those contained in DFND;

(b) The dimensions of the marked channel shall correspond to the dimensions established by the Danube Commission and approved by decisions taken at the forty-fifth and seventy-seventh sessions or the dimensions published by the competent authorities;

(c) The choice of where the signs are to be placed shall be based on the most recent measurements, acquired experience and available data on the state of the fairway, critical points, water levels, etc.;

(d) Signs and marker lights shall be visible whatever the level of the water, at all points of the fairway and as long as may be necessary for the guidance of boatmasters;

(e) The marking plan shall contain information on the type of placed signs, bank/side whereon placed, river kilometre of the set-up and recapitulation of all signs and signals on the water and bank marks used for marking.

2.9 If there is a subsequent drop in the level of the water, reconnaissance soundings shall be taken on some sections of the river in order to check whether the positioning of the signs is adequate and to establish whether the marking needs to be supplemented by new signs.

2.10 The frequency of these soundings shall be determined by changes in water level. The more rapid the drop in levels, the more frequent the soundings need to be.

3. Visibility of signs and lights

3.1 Whatever the position of the vessel in relation to the sign or the marker light, the characteristics of the sign or light shall remain unchanged. For daytime signs, these characteristics are: the form (topmark) and the colour; for signs at night: the rhythmicity and colour of the lights.

3.2 The forms and the colours of the topmarks and the rhythmicity of the lights are set out in detail in Annexes 7 and 8 to DFND.

3.3 In principle, signs and lights must comply technically with Annexes 1, 2, 3 and 4 of this Instruction.

Visibility conditions and dimensions of signs

3.4 The basic requirement to be met by signs and marking is the guarantee of good visibility of all signs and signals by day or night.

3.5 In accordance with IALA recommendations,[1] there are three degrees of visibility of signs and signals:

(a) First: the sign is visible to the naked eye. The meaning of the sign is not yet identifiable (simply visible);

(b) Second: the sign is clearly visible and identifiable according to DFND (identifiable);

(c) Third: the sign is identifiable and distinguishable from its surrounding background (conspicuous).

Signs that must be seen by boatmasters at some imperative distance ("no entry", "keep a particular sharp lookout", etc.) must have a visibility (due to their proper dimensions) of second or third degree. The type and dimensions of signs should be selected accordingly.

Third degree visibility is required when the sign or light is identifiable in principle, but cannot be easily seen at night owing to the surrounding background (presence of construction or a large number of light sources).

3.6 The degree of visibility depends on the following conditions:

Signs:

- Angle of sight;
- Colour contrast and differences;
- Lighting (including natural day light) and weather conditions.

Lights:

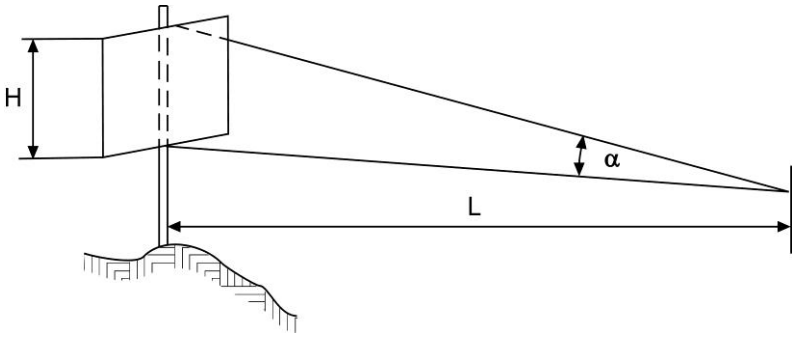
- Luminous intensity;
- Competing lights and background lighting;
- Weather conditions.

3.7 In order to ensure first degree visibility, in daytime the sign must be visible with an angle of the order of 1 angular minute at the least and with sufficient contrast in relation to the environment. The details and colour of the sign (second and third degree visibility) can only be distinguished with a larger angle of sight or with a reduction in the distance L to be object being observed.

3.8 The limit of the viewing angle for signs with simple shapes (cylinder, cone, sphere, etc.) is between 3.5 and 5 angular minutes in daytime. For boatmasters to be able to recognize (without any optical aids) a shape on a sign at appropriate distances and in the corresponding conditions of visibility, the following formula can be used to calculate the required minimum dimensions of simple shapes:

[1] IALA: International Association of Marine Aids to Navigation and Lighthouse Authorities (www.iala-aism.org).

Figure 1a



$$H = L * \mathrm{tg}\alpha \cong L * \sin\alpha ,$$

where H (m) = height of sign;

L (m) = distance;

α (') = viewing angle.

A sample of values for H (m) as a function of L (m) and α (') are presented in Table 1:

Table 1

	α	*L (m)*				
		500	*1 000*	*2 000*	*3 000*	*4 000*
For signs with simple shapes (cylinder, cone, circle, etc.)	3	0.44	0.87	1.74	2.61	3.48
	4	0.58	1.16	2.32	3.48	4.64
	5	0.73	1.45	2.90	4.35	5.80

Table 1 shows that the shape of a sign with a dimension H = 0,5 m is recognizable at distance L = 500 m with a viewing angle α = 4'; when L = 1,000 m, then H = 1 m, etc.

When there are simple drawings (dot, line, arrow) on the signs, a 15 per cent visibility reduction must be taken into account; while with complex drawings it shall be 30 per cent.

3.9 Examples of the minimum measurements for the signs, marks and buoys from Annexes 7 and 8 to DFND are given in Annex 1 to this Instruction. Alphanumeric characters on signs should intend to provide a standard for the various signs.

The letters, figures and analogous symbols should be of a height not less than one five-hundredth of the maximum distance from which they must be read, and the thickness of the stroke should be not less than one seventh of that height.[2]

For bank marks and signs, minimal height of the lower rim of board down to the base of the lowest sign shall be at least 3 m. A height of 2 m is acceptable in sectors where the topography requires it. At the highest navigable water levels, the height between the water surface and the lower rim of the board of the lowest sign shall be established in accordance with local conditions so as to ensure proper visibility.

[2] Text from Resolution No. 22 – Signs and Signals on Inland Waterways (SIGNI) (ECE/TRANS/SC.3/108/Rev.2).

3.10 As regards the signs and signals of Annex 8 to DFND, unlighted buoys and unlighted bank mark boards shall be covered with reflective material. Light buoys and lighted bank mark boards may also be so covered. The colours of these materials shall correspond to those established for the buoy lights or the boards.

3.11 In order to ensure that bank marks are clearly visible, their dimensions shall be determined in terms of their purpose, the distance between the fairway and the banks, the nature of the region and the characteristics or other specific conditions of the sector in question.

3.12 The contrast between the luminance of the sign or signal and the background plays an important role in ensuring the good visibility of a sign or signal. For example, of two boards, one red and the other white, positioned one beside the other against a light background, the red board will be more visible from a greater distance than the white board, while on the other hand the white board will be easier to see than the red board against a dark background. Such circumstances also must be taken into consideration when choosing sites for signs and signals.

3.13 The visibility of signs and signals set out in Annex 7 to DFND regulating navigation on the waterway shall be ensured at night by lighting them with fixed directional white lights, operating uninterruptedly and so positioned that the light does not incommode the boatmasters.[3]

If electric lighting cannot be used, the sign boards may be covered with reflective material of a corresponding colour on which the symbol shall be clearly visible to vessels.

3.14 In order to guarantee the visibility of lighted boards, the back lighting must conform with the requirements of Annex 4 to this Instruction. In Annex 4, in addition to luminance and its regularity, the colour for the white light source is established to ensure that colours under artificial light look the same as when seen in daylight.

For reliable identification at night the surface of the sign must be smooth and even, and if possible reflective.

Conditions for the visibility of lights

3.15 In certain cases lighting may be provided at night (e.g. lighting or the lower part of a bridge, of the piers of a bridge, of the approaches to a lock, of a section of a canal, etc.). Such lighting may be used to supplement the markings. Lighting shall be so designed as to avoid dazzling.[4]

3.16 Luminous intensity is broken down into three classes in terms of navigation lights for inland waterway vessels (see Annex 2 to this Instruction).

3.17 Light signals are identified according to their characteristics. The characteristics are given by their colour and the rhythmicity the light source, in accordance with Annex 8 to DFND.

Obligation not to hinder road and rail traffic

3.18 Signs and marking shall be installed in such a way that their lights do not hinder the movements of other modes of transport if the road runs close to the river.

3.19 In a sector in which a road or a railway runs close to a river, the installation of all the above-mentioned signs and signals shall be carried out in consultation with the respective competent authorities.

[3] The competent authorities may waive these obligations.

[4] Text from SIGNI.

4. Installation of signs and marking in the characteristic sections of the river

4.1 General

4.1.1 Signs have two possible orientations, namely:

(a) Parallel to the axis of the fairway;

(b) Perpendicular to the axis of the fairway.

4.1.2 Signs of type (a) are predominantly prohibitory or indicative signs and are placed on the side of the fairway to which the prohibition or the indication applies.

Bank marks which are used in relation to navigation in both directions (upstream and downstream) shall be oriented as under (a). In some cases (better visibility), the angle between the mark and the axis of the fairway can be 10° or less (fig. 1, sign a).

4.1.3 Most signs are installed as set out in (b) and generally do not apply to one side of the fairway only. These signs are erected at right angles to the axis of the fairway so that they are visible to a user under way.

Bank marks which are used in relation to navigation in one direction (upstream or downstream) shall be oriented as under (b). In some cases (better visibility), the angle between the mark and the axis of the fairway cannot be less than 60° (fig. 1, sign c).

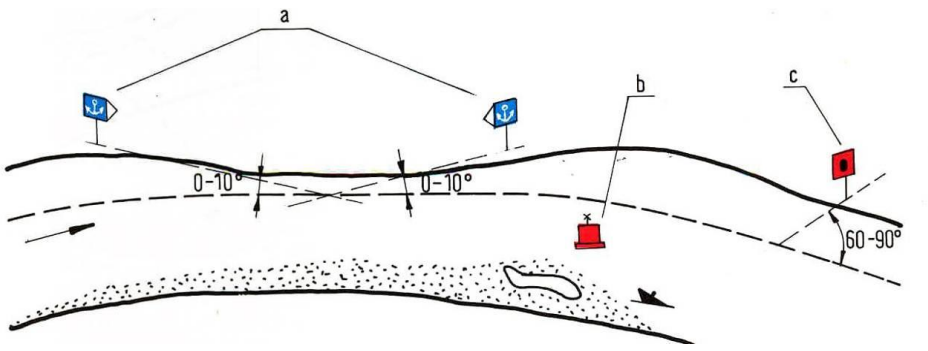
4.1.4 The use of a particular sign or signal on the water or bank mark and how it is installed depends on the one hand on the local features of the river (speed of current, variation in levels, meanders, width of the bed, existence of sills, branches, islands, etc.), and on the other hand on the density of traffic in a given sector and the form and size of convoys.

4.1.5 The position of each sign or signal on the water indicating the side of the fairway shall be determined on the basis of the marking installation plan based on the results of measurements. Depths within the limits of the width of the marked fairway shall under no circumstances be less than the minimum depth reported for the sector in question.

4.1.6 When signs and signals are installed on the water, it is essential to take the direction of the current into account. If the current flows in the direction of an obstacle, the sign or signal shall always be placed a long way from the navigational hazard (obstacle); if, on the other hand, it flows in the opposite direction, the sign or signal shall be placed nearer.

4.1.7 Obstacles on the sides of the fairway are always marked with signs or signals on the water. When the obstacle is indicated by a single sign, it shall be placed on the upstream extremity of the obstacle, on the fairway side (fig. 1, sign b).

Figure 1



4.1.8 As a rule, lighted buoys or unlighted buoys shall be used to mark the upstream and downstream extremities of sills, banks which narrow the fairway in meandering sectors, banks protruding into the fairway, piles of stones, reefs, water supply engineering structures, and underwater hazards or obstacles (sunken vessels, anchors, etc.).

4.1.9 Marker posts and spars shall be used as additional signs supplementing buoys in order to give a clearer indication of the limits of the fairway over difficult sills and in order to mark underwater obstacles. In some cases and in some sectors, buoys may be replaced by marker posts or spars.

4.1.10 On sectors of the river where there is day and night navigation, forks, junctions and the axis of the fairway along with obstacles to navigation lying within the fairway shall be marked by light buoys or bank lights or signs. Signs and signals on the water shall be installed at such a depth and at such a distance from the obstacle that the safety and ease of movement of vessels shall be guaranteed at night and in poor visibility.

4.1.11 On sectors where the bed is narrow, marks on the banks shall be used.

4.1.12 Each sign or signal on the bank shall be established following reconnaissance of the area and selection of the most appropriate site. The need to ensure the visibility of the sign whatever the level of the water should be taken into consideration.

4.1.13 If it is necessary to ensure good visibility of the symbol on the sign over a long distance, both for vessels proceeding upstream and vessels proceeding downstream, two boards may be installed on the sign pole at an angle to each other, one pointing upstream and the other downstream.

4.1.14 In selecting the site of a sign or signal on the bank, account shall be taken of the need to ensure easy maintenance and to protect it against ice and flooding.

4.1.15 Before a bank sign or signal is installed, the depths in the area in front of it and in the direction it indicates shall always be measured.

4.1.16 As a general rule, the objective is that only the network of signs and signals on the bank shall provide an uninterrupted indication of the position of the fairway, while the signs and signals on the water shall help boatmasters to determine the limits of the fairway.

4.2 Marking of meandering sectors

4.2.1 Installation of cross-channel fairway signs and bank lights

4.2.1.1 Cross-channel fairway signs and bank lights may be used in meandering sectors in order to indicate that the fairway crosses over from one bank to the other (signs featured in C.4, D.4, C.5, D.5 in Annex 8 to DFND).

4.2.1.2 Cross-channel fairway signs and bank lights are placed when the fairway is sufficiently broad, its safety is ensured, and the direction requires only an approximate indication.

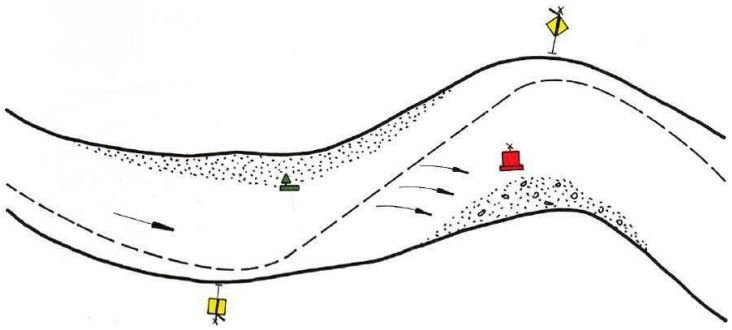
4.2.1.3 Bank lights and cross-channel fairway signs shall be selected in such a way as to differentiate cross-channel fairways in terms of their length, in other words in terms of the distance between two neighbouring signs. The length of the cross-over is relative, since it depends on the width of the fairway.

4.2.1.4 The maximum range of the cross-channel fairway signs and bank lights is 3 km. On such sections, cross-channel fairway signs and bank lights (without signs on the water) can be placed provided that the width of the fairway is more than two times wider than the minimum width for a particular sector. If, on the other hand, the width of the fairway is less than the minimum planned width, the cross-channel fairway signs and

bank lights (without signs on water) may be installed at a maximum distance of 1-1.5 km from each other.

4.2.1.5 In case the direction of the current makes an angle with the fairway, when strong side winds or a similar situation occurs, the fairway can be marked by additional navigation marks according to the local conditions (fig. 2).

Figure 2

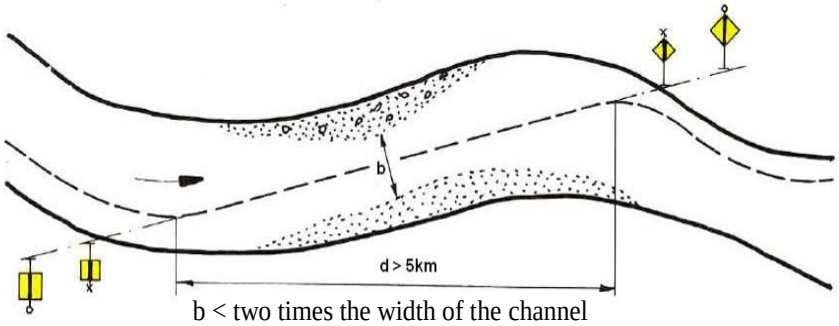


4.2.1.6 When the fairway follows the middle of the river bed over a long distance or when it crosses abruptly from one bank to the other, its axis may be indicated by two marker posts, as shown in figure 3.

The advantage is given to two cross-channel fairway signs on each side of the fairway in case of straight-line sections longer than 5 km, where the available width for navigation is less than double the width of the minimum prescribed width of the fairway for a particular sector. In that case and when the bank configuration allows so, the cross-channel fairway signs are placed on both margins of the transition (fig. 3).

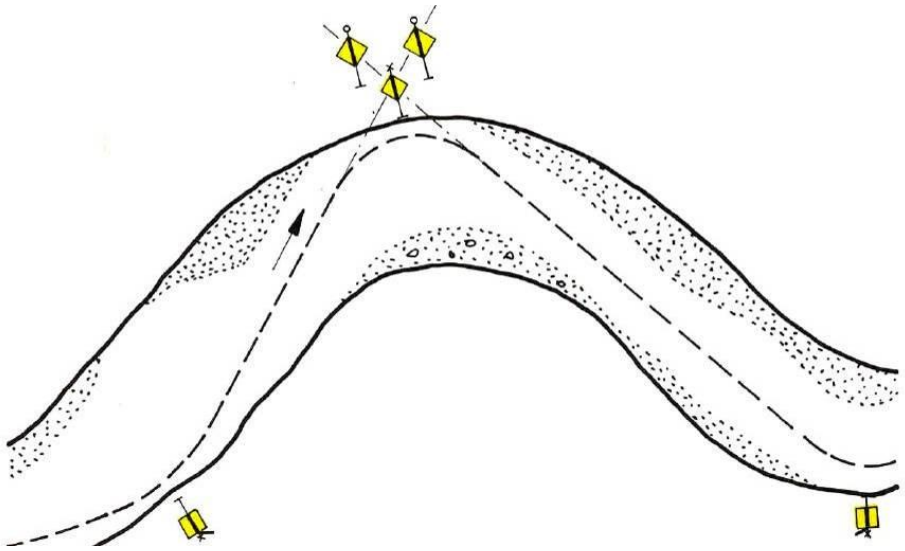
The advantage is also given to placing two cross-channel fairway signs on each side of the fairway when the fairway is narrowed by certain obstacles constituting threats to navigation or other hazards marked by signs and signals on the water.

Figure 3



4.2.1.7 In sectors where the fairway, after moving to the opposite bank, abruptly crosses to the other bank, triple marker posts must be placed (the first sign shall have 2 boards; see figure 5). In this case, the lights of the rear marker posts shall be oriented strictly on the axis of the fairway, one upstream and the other downstream.

Figure 4



4.2.1.8 Interrelationships of the front and back signs at hidden routes shorter than 4 km are presented in table 2.

Table 2

L (m)	*d (m)*	*h_o (m)*	*a (m)*	*2a (m)*
200	17	8.50	2.6	5.0
300	25	8.70	4.0	8.0
400	33	8.85	5.2	10.5
500	42	9.00	6.5	13.0
600	50	9.10	8.0	16.0
700	58	9.20	9.0	18.0
800	67	9.35	10.0	20.0
900	75	9.50	12.0	24.0
1 000	83	9.60	13.0	26.0
1 500	125	10.25	19.0	38.0
2 000	166	10.90	26.0	52.0
2 500	207	11.50	33.0	66.0
3 000	250	12.15	39.0	78.0
3 500	290	12.75	46.0	92.0
4 000	330	13.40	52.0	104.0
> 4 000	760	14.20	25.0	50.0

Where

L (m) = length of maximum distance over which marker posts may be efficiently used.

d (m) = distance between the front and the rear markers (= at approximately 1/12 of *L*).

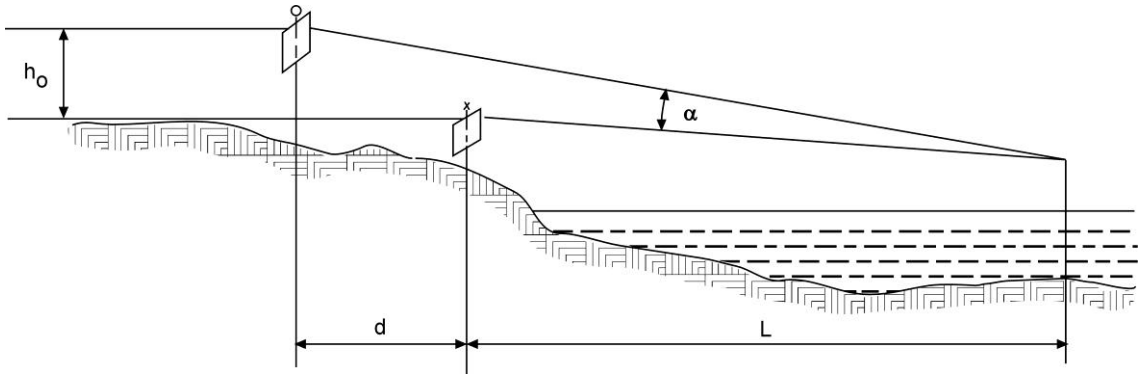
h_0 (m) = distance in height between the lights of the front and rear marker.

a (m) = distance necessary for a vessel to adjust its course if the vessel does not go along the cross-channel fairway.

α (°) = viewing angle.

Table 2 has been prepared also on the assumption that the observer's eye is at a height of 5 m from the surface of the water and that the light of the marker post (front marker) is 8 m from the surface of the water.

Figure 1b



Value "a" in the table describes the precision of the alignment. The value is very important when the vessel passes through a narrow fairway. As a rule, the precision increases the closer to the marker post.

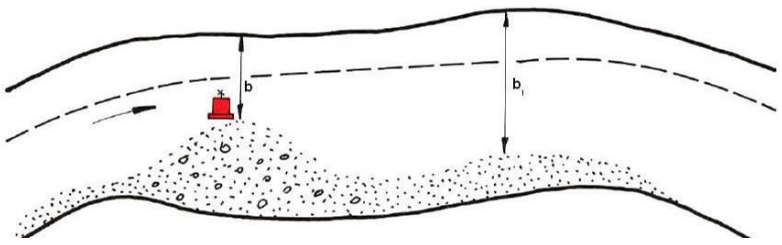
In order to ensure that marker posts — and their lights during the night — are visible, the angle of sight α (°) must be at least 4° in relation to the vertical.

4.2.2 Installation of signs and signals on the water

4.2.2.1 In meandering sectors, where the fairway passes along the middle of the river bed, or along the bank or passes slowly from one bank to the other, signs and signals on water are used to mark formations in the river bed or obstacles, both natural and artificial, on the sides of the fairway (banks, shores, islands, stones, sunken vessels, wrecks of bridges, etc.), when these obstacles protrude into the fairway and reduce its width (fig. 5).

These underwater obstacles are marked in meandering sectors by signs and signals on the water if, within the limits of width indicated above, the depth of water over such obstacles does not exceed the minimum depth reported for the sector. If the obstacle is not very wide, a light signal shall be installed on the water on its upstream section. A marker post or a spar may be installed on its downstream section, depending on its length.

Figure 5

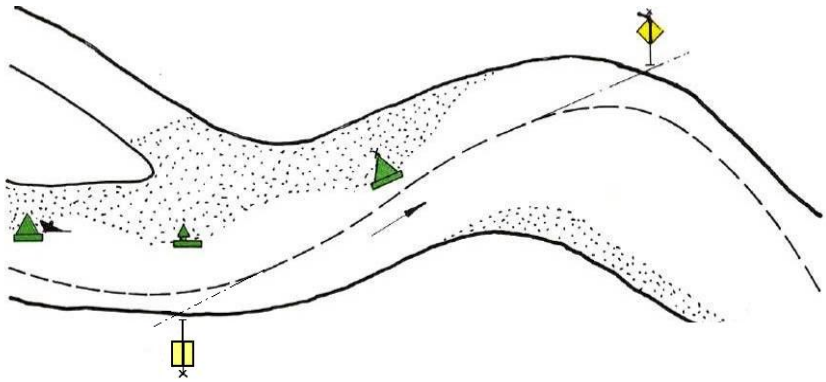


b < twice the width of the fairway

b_1 > twice the width of the fairway

4.2.2.2 The signs and signals on the water marking underwater obstacles of considerable length are so installed that the parts situated closest to the fairway are marked by light signals between which unlighted signs may be placed, thus enabling a given obstacle to be marked completely (fig. 6).

Figure 6



4.2.2.3 In meandering sectors, the bank marking system in periods of high water generally remains the same as in periods of lowest water level, except in sectors where, when water levels are high, it is advisable to find another fairway with better navigational features. In this case, the selected fairway shall be marked appropriately.

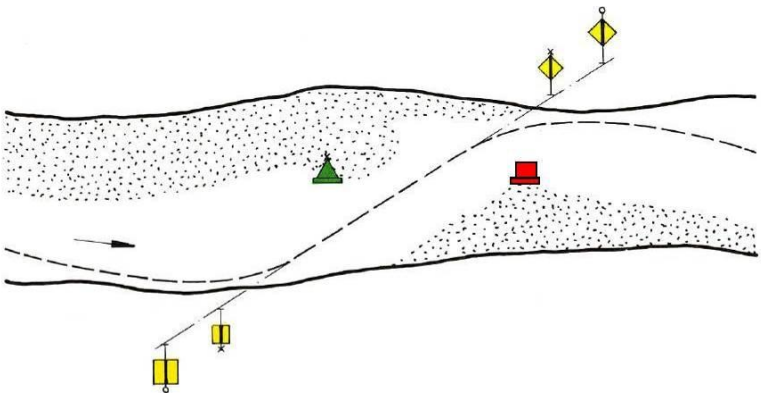
4.3 Placement of signs over sills

4.3.1 In the case of both sills and other sectors, the principle of the continuous marking of the direction of the fairway, i.e. from one sign to the next, should be observed.

The fairway over sills may be marked by cross-channel fairway signs, bank marks and lights and signs and signals on the water.

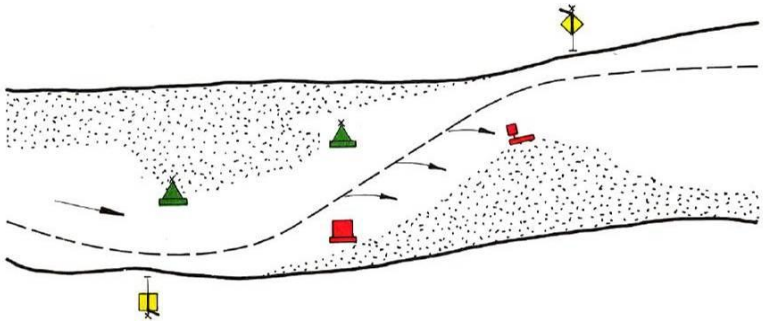
4.3.2 Alternately located sills may also be marked by marker posts, with sufficient available width for navigation in which vessels are passing in a straight line (fig. 7).

Figure 7



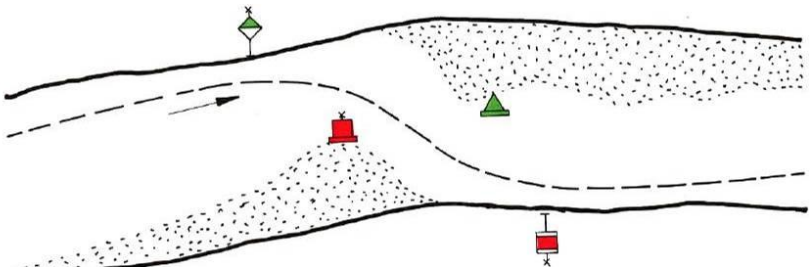
4.3.3 A fairway passing over sills is usually marked by signs and signals on the water (fig. 7 and 8).

Figure 8



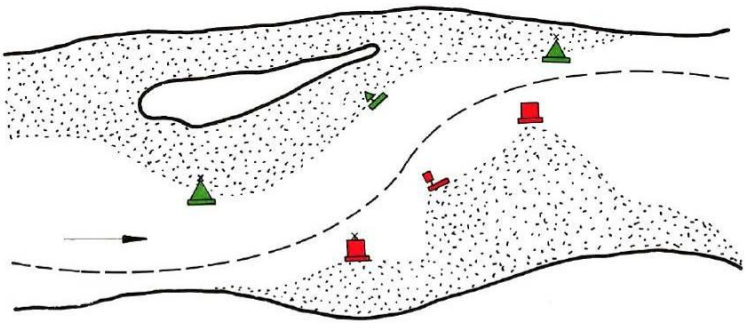
4.3.4 If the fairway passes in a straight line between sandbars, reaching far into the riverbed, it is necessary to place at least two signs on the water at the entry and the exit of such a section: one at the top of the upstream and one on the top of the downstream sandbar (fig. 9).

Figure 9



4.3.5 If the fairway is curved in the section between sandbars, it is necessary to place additional signs on the water (fig. 10).

Figure 10



4.3.6 Additional signs on the water taking into account cross currents shall also be placed on the entry and exit of rugged sections with sandbars.

4.3.7 If it is impossible to use cross-channel fairway signs, the fairway across the sill may be marked only by double or single signs on the water, depending on its width and taking hydrological factors into account.

4.4 Marking of the vicinity of bridges and passages through bridges

4.4.1 The navigation of vessels and convoys in the vicinity of bridges and through bridge passages requires particular attention and precautions on the part of boatmasters because of the narrow fairway. These sections must therefore be marked with the greatest care.

4.4.2 The basic condition to be met to ensure safe passage through bridges is the marking of the direction of the fairway and also, where necessary, its sides. Signs and signals on the water and on the banks may be used in addition to boards and lights for marking the navigable passage through bridges.

4.4.3 The choice and positioning of the signs depends in each case on local conditions in the bridge section.

4.4.4 The installation of marking signs in the vicinity of bridges and the buoying of navigable passages shall comply with the following conditions:

(a) In order to indicate permission to use the navigable passage of a bridge, only signs A.10, D.1 or D.2 in Annex 7 to DFND shall be used;

(b) The installation of marking signs shall be based on depth and current direction measurements, both in the immediate vicinity of the bridge and in the approach sections;

(c) The positioning of the signs installed in the vicinity of a bridge shall be modified in due course, as conditions of navigation change;

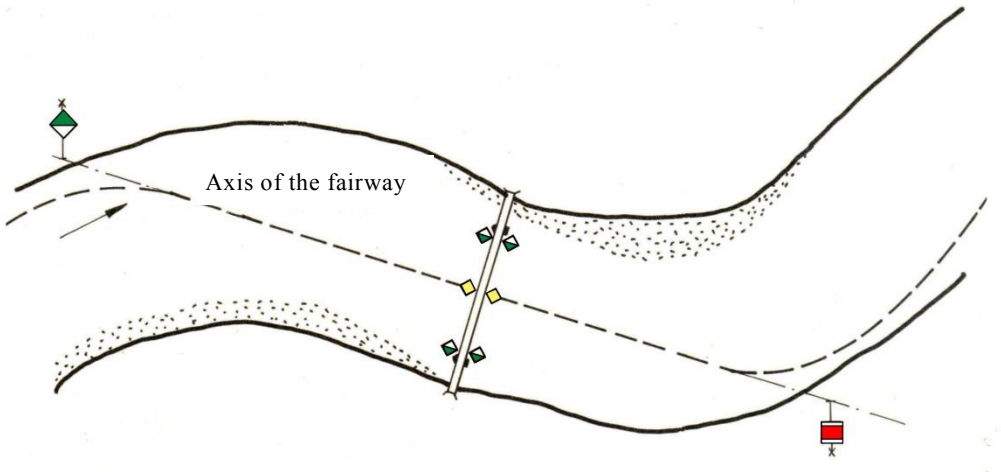
(d) If, when approaching the bridge or in the navigable passage the direction of the current forms an angle with the bridge, giving rise to eddies around the pillars of the bridge, the signs on the water shall be so installed as to indicate the direction of the eddies.

4.4.5 Signs and signals may be installed on the water at the approach to the navigable passage to give an exact indication of the position of the fairway.

4.4.6 The following examples show the placement of the aforementioned signs marking the section near bridges:

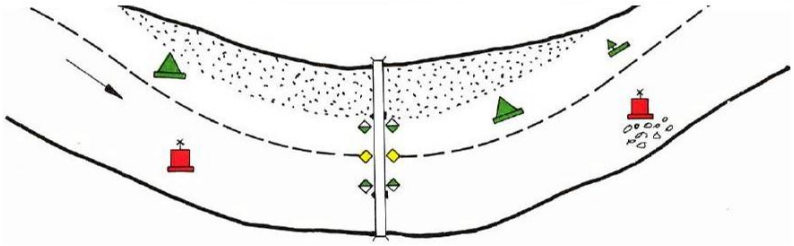
(a) If the bridge is located on a winding section of the river, bank marks may be used to facilitate the passage of vessels in the navigable passage (fig. 11);

Figure 11



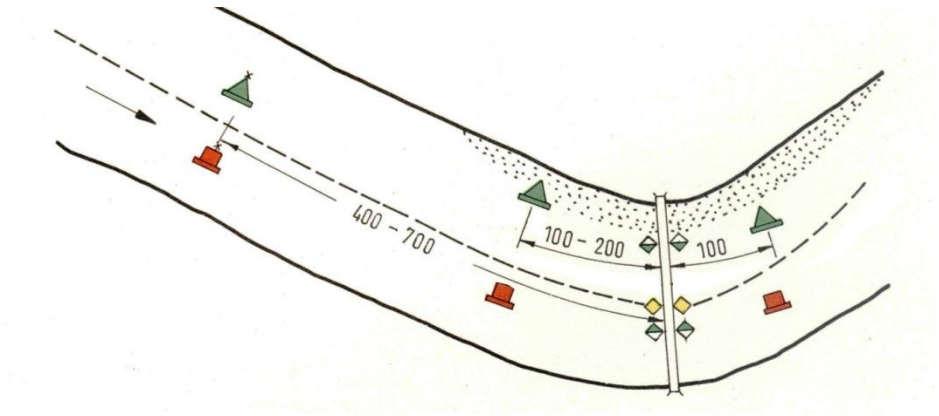
(b) Where it is not possible to use the bank marking mentioned above because the fairway is winding or for other causes which are the result of local conditions, signs and signals on the water (buoys, etc.), placed to follow the river flow, may be used (fig. 12);

Figure 12



(c) If the bridge is located in a sector of the river where the direction of the current on approaching the bridge forms an angle with the axis of the navigable passage, marking upstream from the bridge may comprise two pairs of buoys. One pair of buoys is placed at a distance of 100 m — 200 m upstream of the bridge, and a second pair, 400 m — 700 m upstream of the bridge. The second pair of buoys shall be so installed that the layout of the fairway they indicate with the first pair corresponds to the direction of the current. Another pair of buoys may be placed downstream of the bridge at a distance of 100 m from the bridge (fig. 13).

Figure 13



4.5 Installation of signs and signals on the water restricting berthing points

Where there is increased intensity of vessels' traffic and the substantial accumulation of vessels in inner harbour basins of ports, on the Danube, in order to restrict berthing places, signs and signals on the water should be used in addition to signs and signals on the banks.

4.6 Reference numbers on buoys and markers

4.6.1 On buoys and markers the use of alphanumeric characters and capital letters is possible. Where both letters and figures are used, their heights should be the same. Where two such combinations occur, as on junction markers, a hyphen should be used.

4.6.2 Characters should not be less than 200 mm high, white on red or green buoys, or black on yellow buoys.

4.6.3 The characters on a lighted buoy can be black on a white background. Signs are usually affixed to special nameplates. It is recommended that the characters be displayed on both sides of buoys.

5. Variable message signs to regulate traffic

When variable message signs are used to regulate traffic, attention must be paid to the following:

(a) If variable message signs regulating traffic show images of signs from Annex 7 to DFND, the images must be depicted using a mechanical display system (e.g. trilon, rotary drum display, board operated using a band drive). Annexes 1 and 3 are applicable with regard to colour selection and dimensions;

(b) By night, mechanical display systems shall be externally lit. Annex 4 shall be applicable;

(c) The use of auto-illumination display systems should be avoided for the signs in Annex 7 to DFND. Inverse representation (e.g. inversion of black and white surfaces for prohibitory signs) shall not be allowed;

(d) A remote controlled auto-illumination matrix display may constitute a reasonable alternative in order to indicate frequently changing information, such as water levels and the height of navigable passages through bridges. Technically, it is possible to display images using light emitting diodes, liquid crystals and light guides;

(e) By day, there must be sufficient luminosity to ensure the sign can be read; by night, luminosity must be reduced in order to prevent any dazzling and to ensure that the sign can be identified. The image must thus be regulated according to light measurements in the surroundings.

Examples of variable message signs to regulate traffic are contained in Annex 5.

6. Installation of radar reflectors on marking signs and signals and navigable passes through bridges

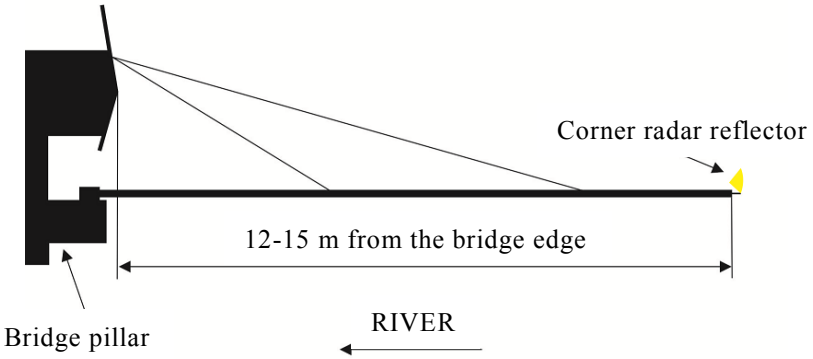
6.1 It is necessary to equip signs on the water and on the banks with radar reflectors to ensure their visibility for radar navigation.

6.2 When marking signs equipped with radar reflectors are installed, account must be taken of the furthest distance between the vessel and the sign in terms of the perception of the sign on the radar screen. This distance between the vessel and the sign depends on the functional characteristics of the radar equipment, the reflective capacity of the radar reflectors and the specific conditions of the river and the height of the antenna, as well as the height of the radar reflector, both in relation to the water surface.

6.3 Vessels and other objectives and objects floating on the surface of the water can be perceived and distinguished on a radar screen as clearly separate from each other depending on the functional characteristics of the radar equipment, the distance to the objective, the distance between objectives, etc. Generally speaking, two objects are perceived as clearly separate from each other when there is approximately 15 m of distance between them in the direction from the observer. For two objects which, from the point of view of the observer, are separated from one another, the distance depends on the size of the antenna and the distance of the observer. From a distance of 1 km and with an antenna of 1.8 m, the distance between objects is approximately 25 m.

6.4 Since the visibility of bridge pillars is usually insufficient on radar screens, the bridge pillars for the passage of vessels upstream and downstream must be marked either by buoys equipped with radar reflectors placed not less than 15-20 m before the bridge, or by radar reflectors installed on the bridge itself not less than 12-15 m from the bridge construction (fig. 14). A sketch of the recommended radar reflector is contained in Annex 1.

Figure 14



6.5 Since radar reflectors are beyond any doubt reliable, every effort should be made to install them by means of supports on the framework of bridges to mark the navigable passage through the bridge.

6.6 Navigational hazards and water supply engineering structures (sunken vessels, groynes, cross-beams, etc.) located in the river bed may also be marked by signs equipped with radar reflectors. If the groynes or cross-beams marked by radar signals are located along one of the banks while the fairway follows the opposite bank, which is low and flat, the radar reflector signals may also be placed on that bank so as to facilitate the orientation of vessels navigating by radar.

6.7 When radar reflectors are used on marking signs and signals, the visibility of the sign or signal must not be diminished. Their colour shall also correspond to the colour of the sign or signal in question.

6.8 Radar reflectors on fairway buoys are most often manufactured using two vertical metal plates set as a cross, with a horizontal metal plate intersecting them at a right angle. The reflectors should be made of aluminium or stainless steel.

6.9 Practical experience has shown that there is a need for at least two standard sizes of reflectors on buoys and markers. Recommended dimensions are as follows:

Type 1: tip-to-tip height 420 mm;

Type 2: tip-to-tip height 850 mm.

6.10 The square plate referred to above has a diagonal of 300 or 600 mm respectively and sides of 210 or 425 mm respectively. A sketch of the reflector is contained in Annex 1.

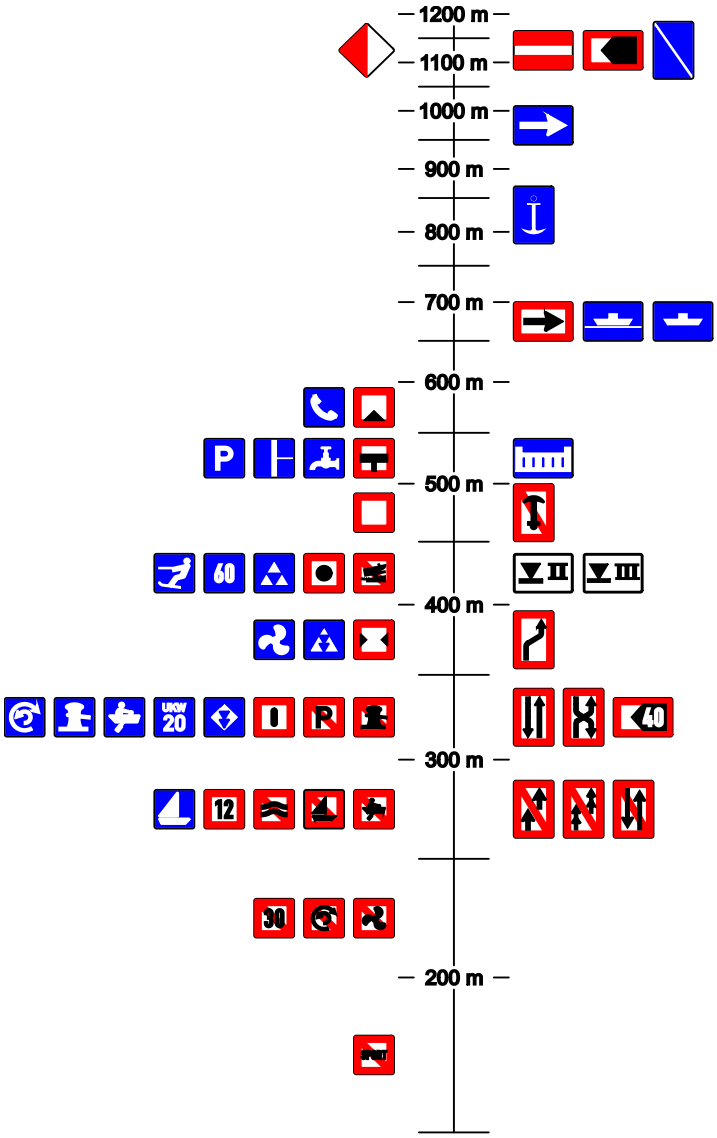
Annex 1

Minimal dimensions of the signs from Annexes 7 and 8 to DFND

Guidance on the maximum distances at which the various signs are visible is given in the figure below. The distances are valid for boards with dimensions of 100 cm x 100 cm and 150 cm x 100 cm, with the observer positioned at a right angle to the surface of the board. When using boards of other dimensions, the distance at which the sign is visible should be recalculated according to the chosen scale.

Sign images:

Fig. 1



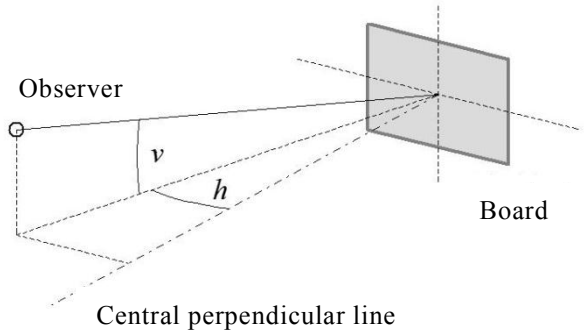
Characters:

For many types of European characters (e.g. DIN 1451), when using black type on a white background, the maximum readability distance D — if the observer is positioned at a right angle to the surface of the board — is approximately D ≈ 465 x h, where h equals the height of the character (height of capital letters above the line).

Viewed at an angle:

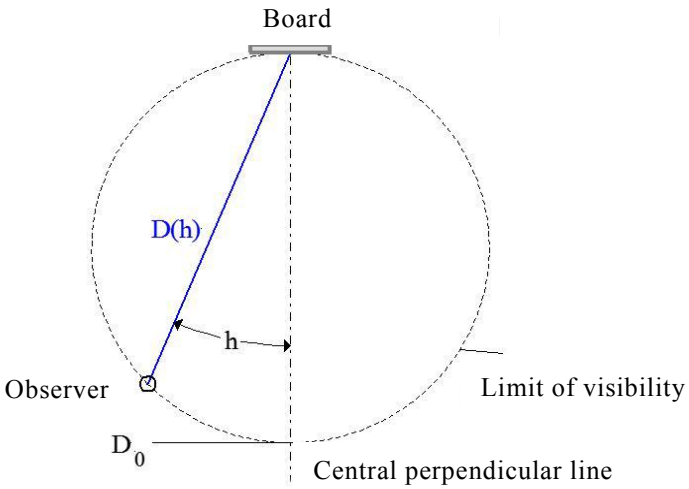
If seen askew, the maximum visibility or readability distance of the board is reduced each time by the cosine of angles h and v between the observer and the central perpendicular line: $D(h, v) = D_o \cos(h) \cos(v)$.

Fig. 2



When the observer is at a great distance, the vertical angle shall be considered to be approximately 0: v ≈ 0. In such cases, the following formula can be used as guidance to determine the visibility distance: $D(h, v) \approx D(h) = D_o \cos(h)$. The area of visibility is thus a circle with a diameter of D_0.

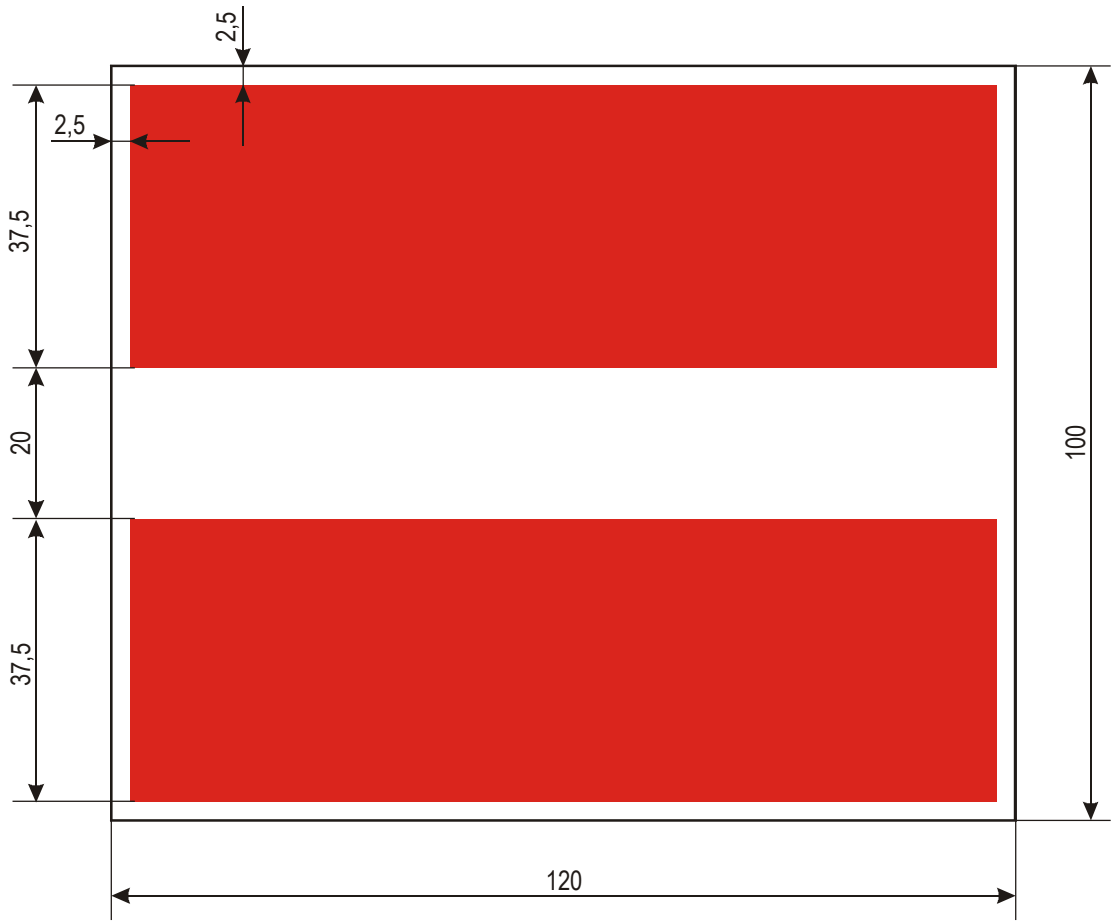
Fig. 3



Note: Etude de la perceptibilité des symboles et des inscriptions sur les signaux de navigation (Study of symbol and inscription visibility on navigation signs), Gerdes, paper presented at the 1990 International Conference on Maritime Signs.

Signs contained in Annex 7 to DFND

A. 1



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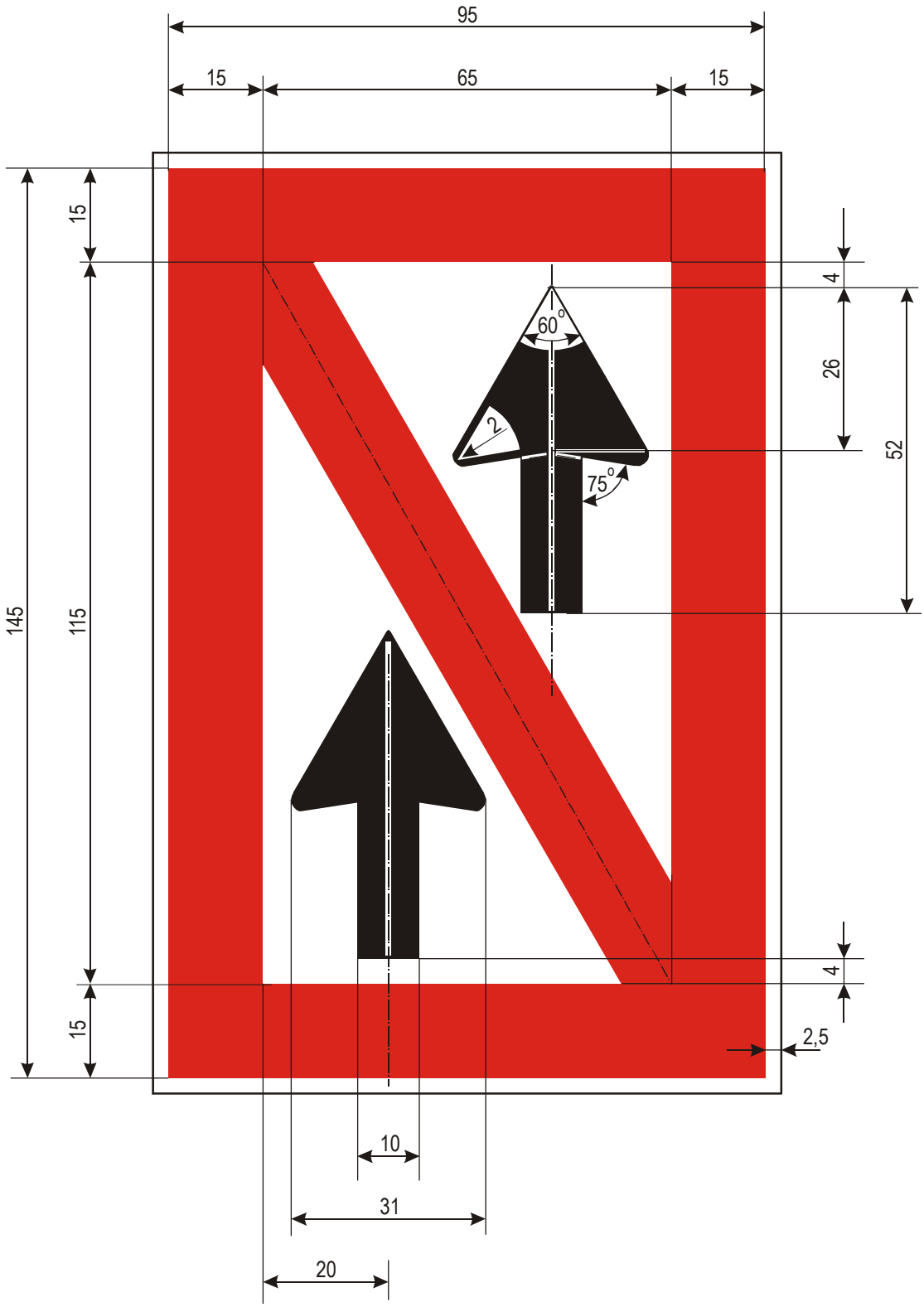

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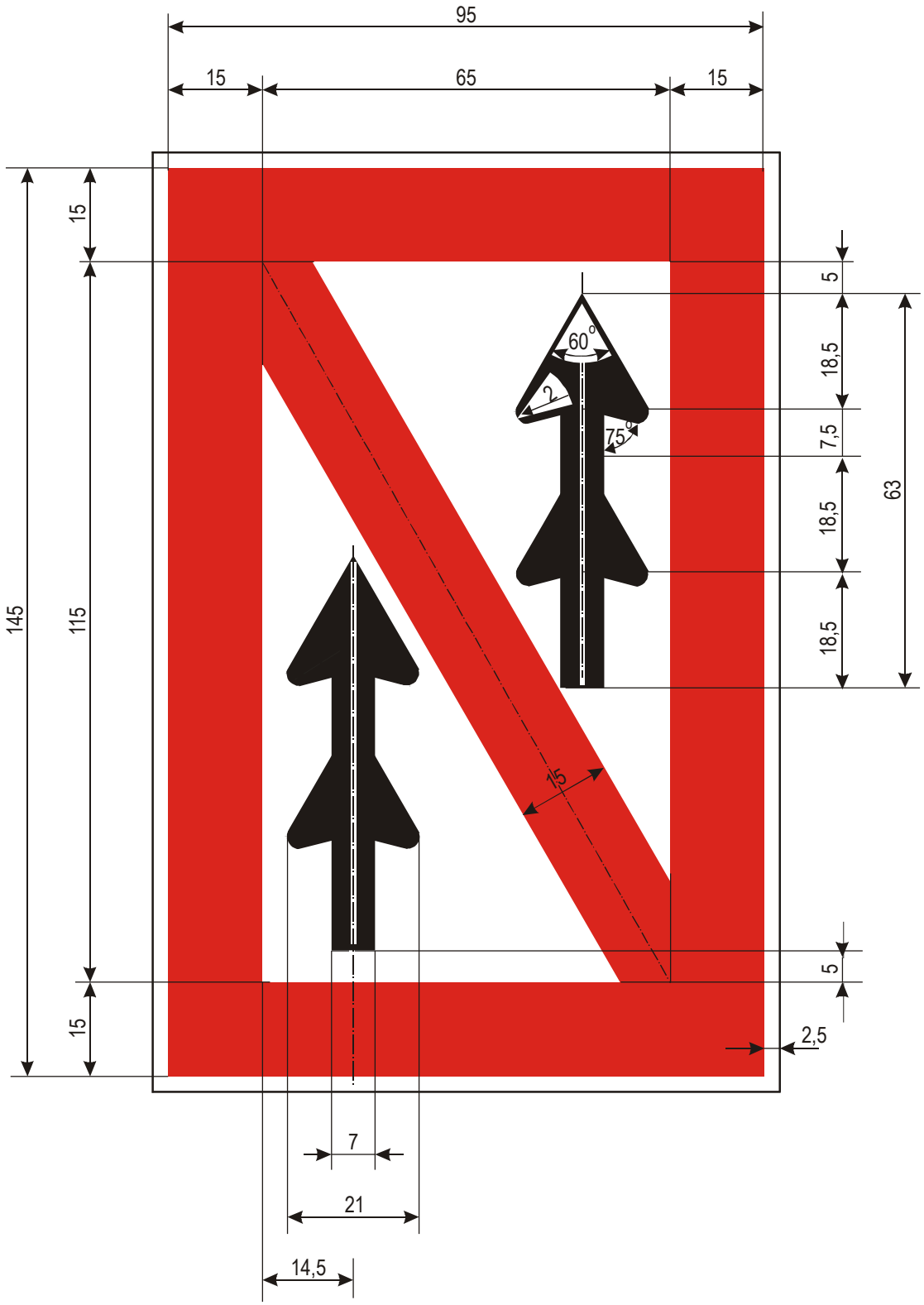
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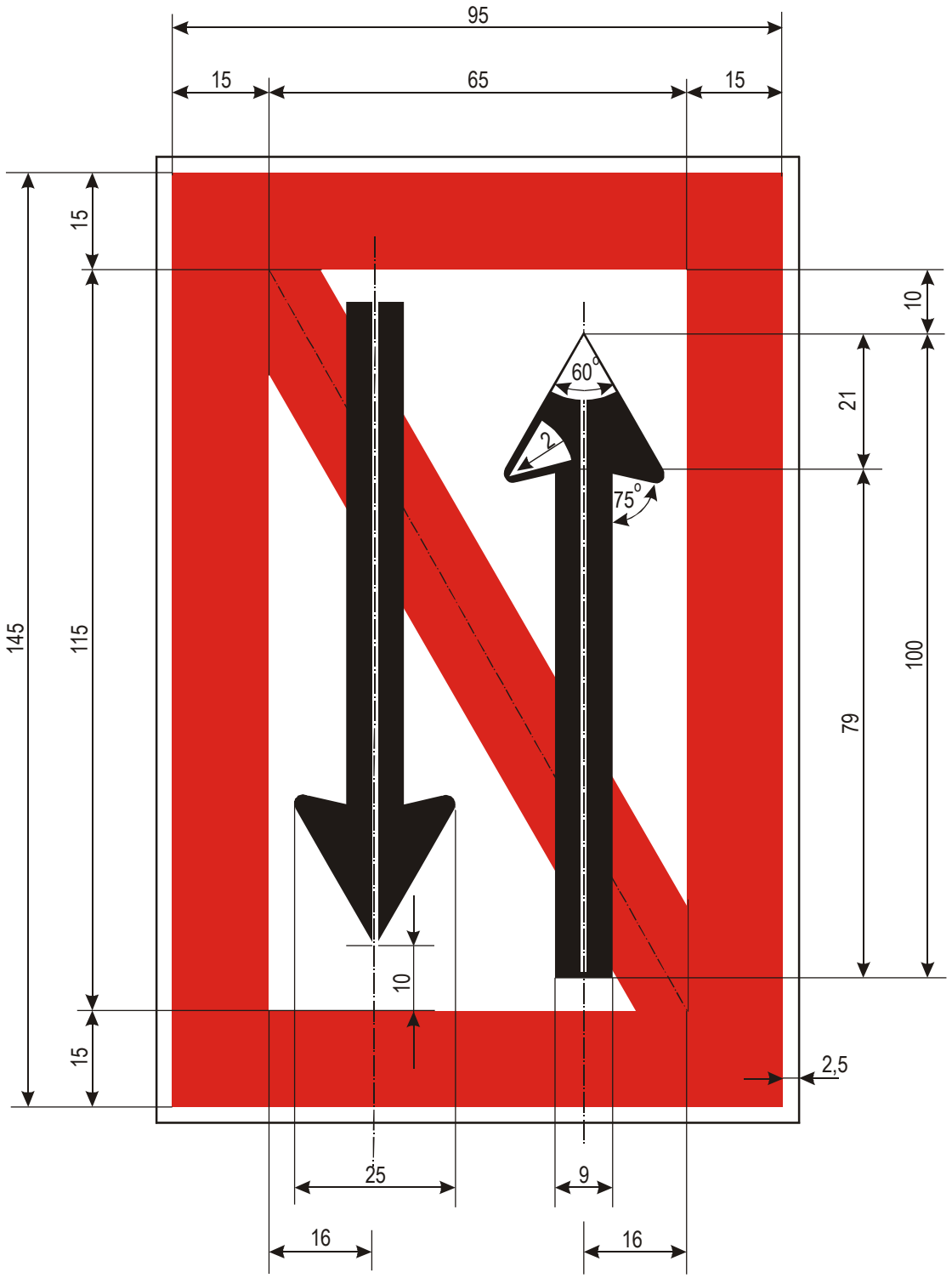
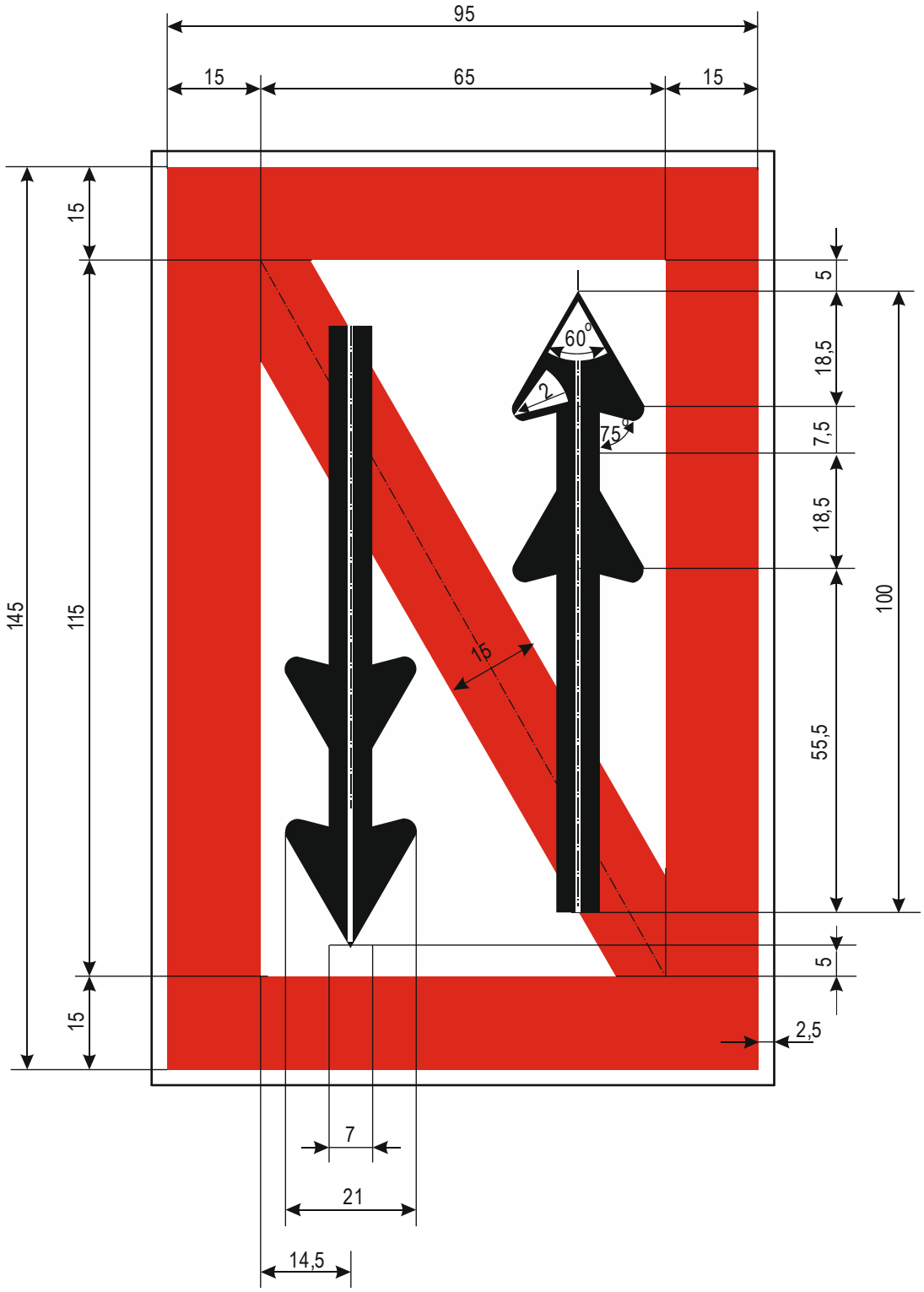
A. 4



A. 4.1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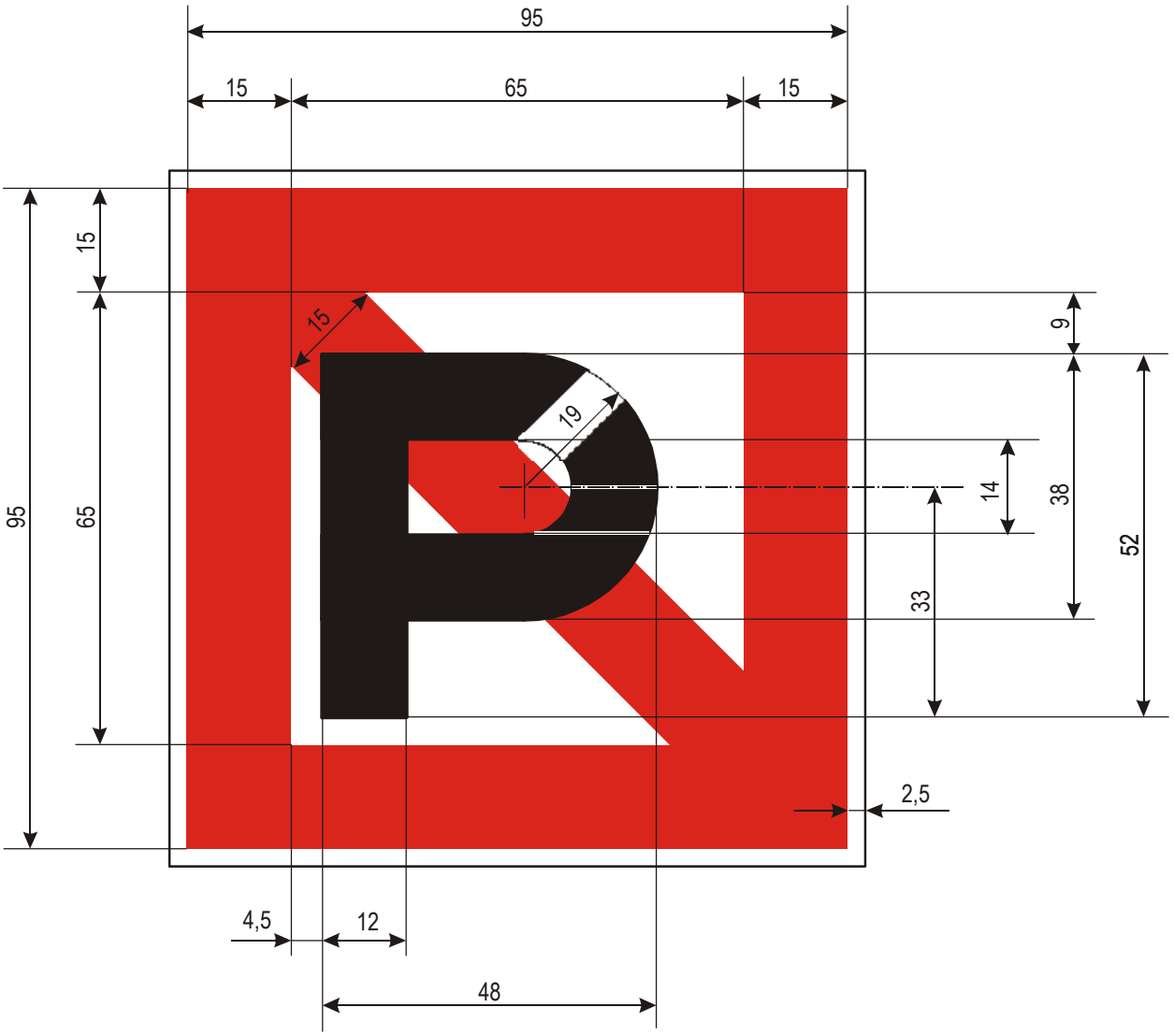
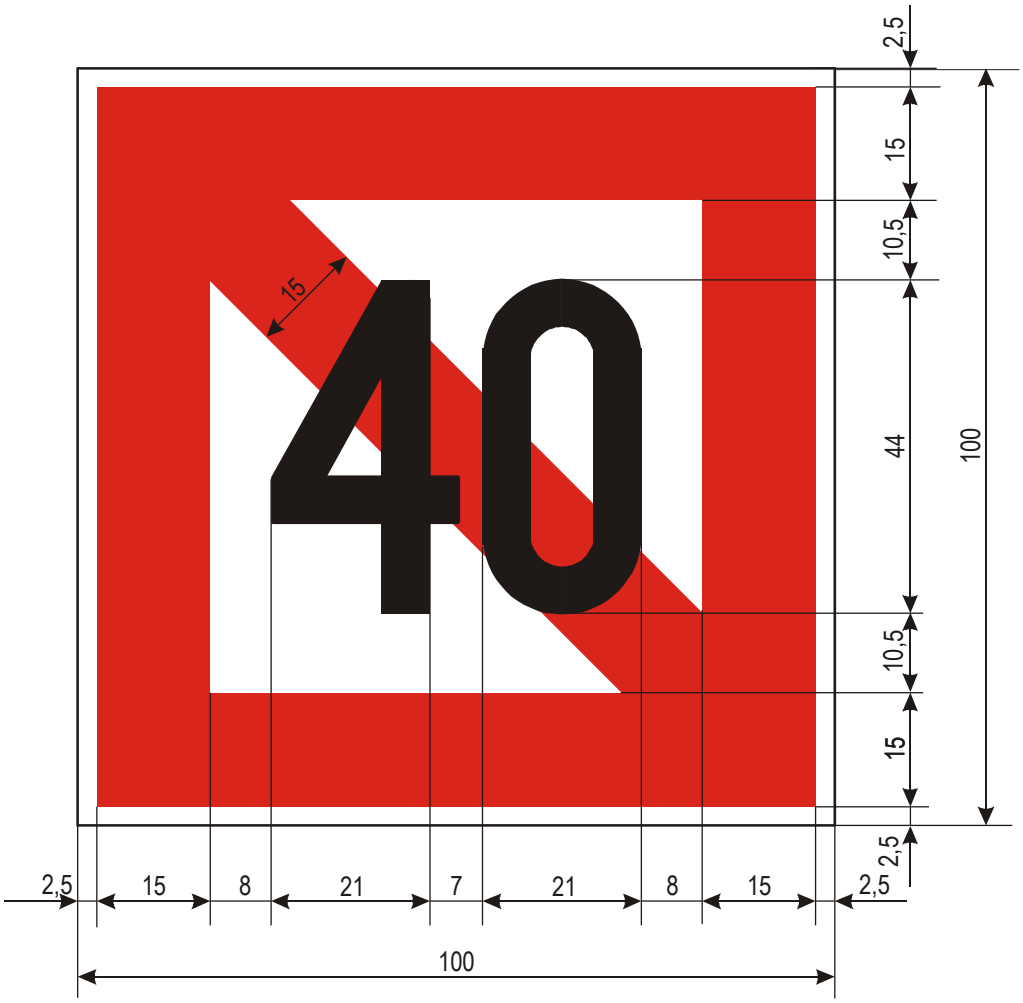
A. 5



A. 5.1



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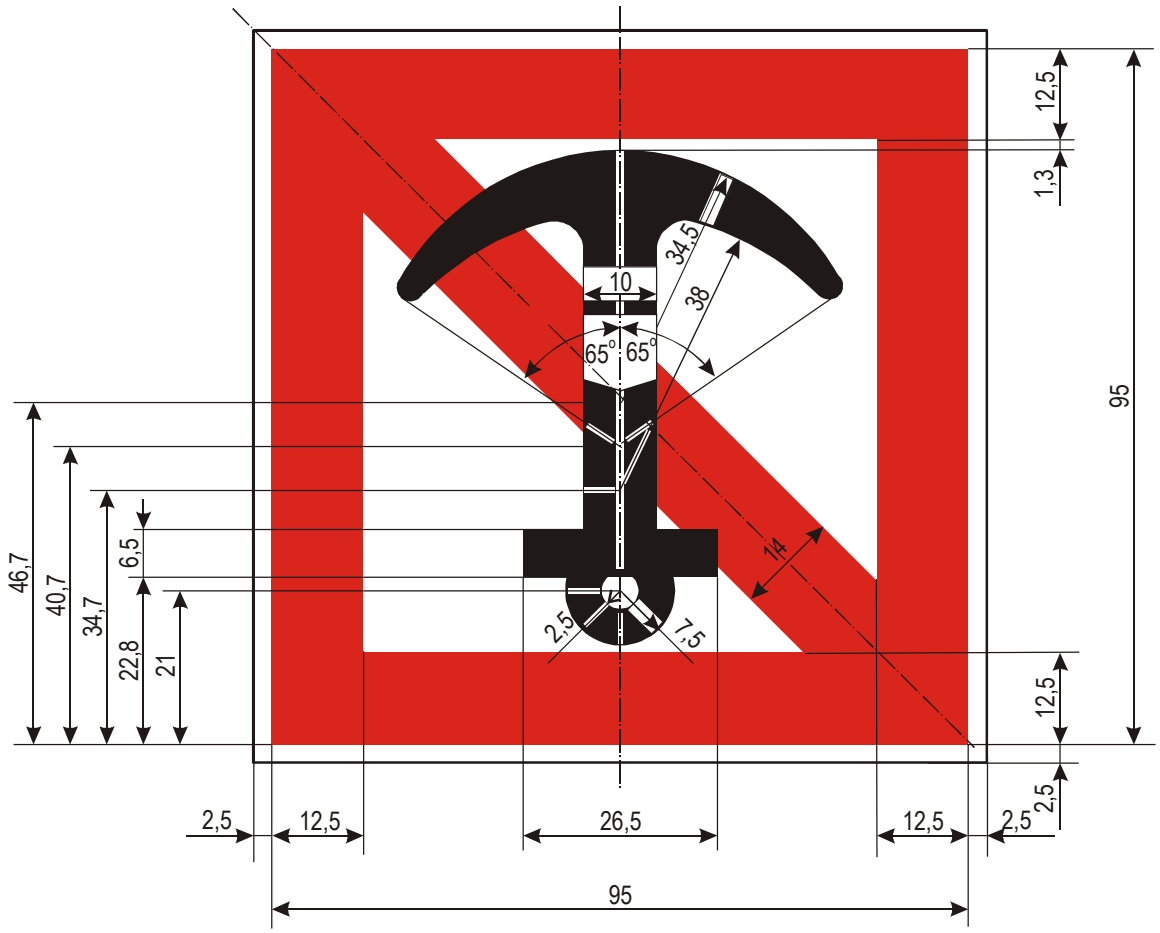
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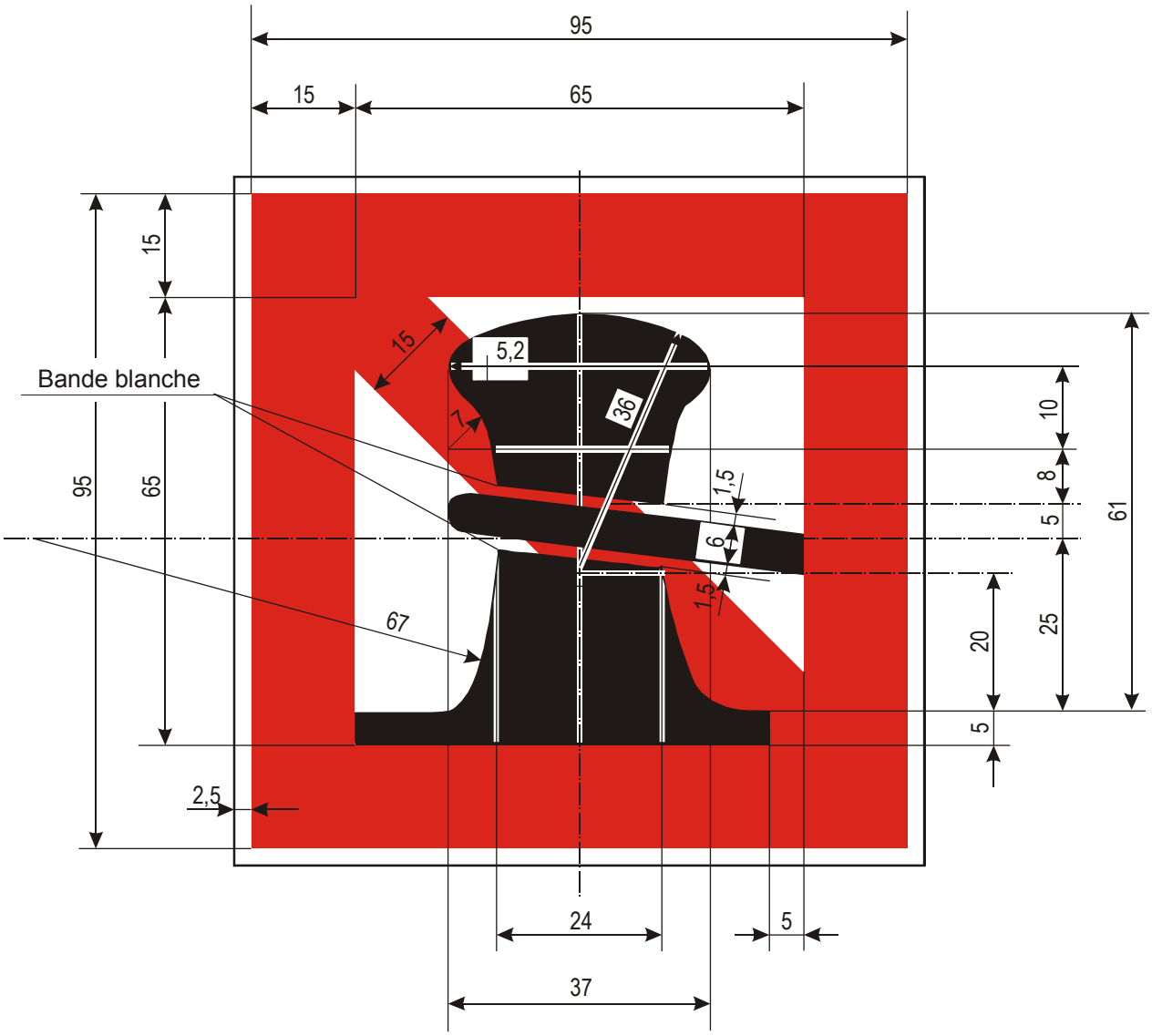
A. 7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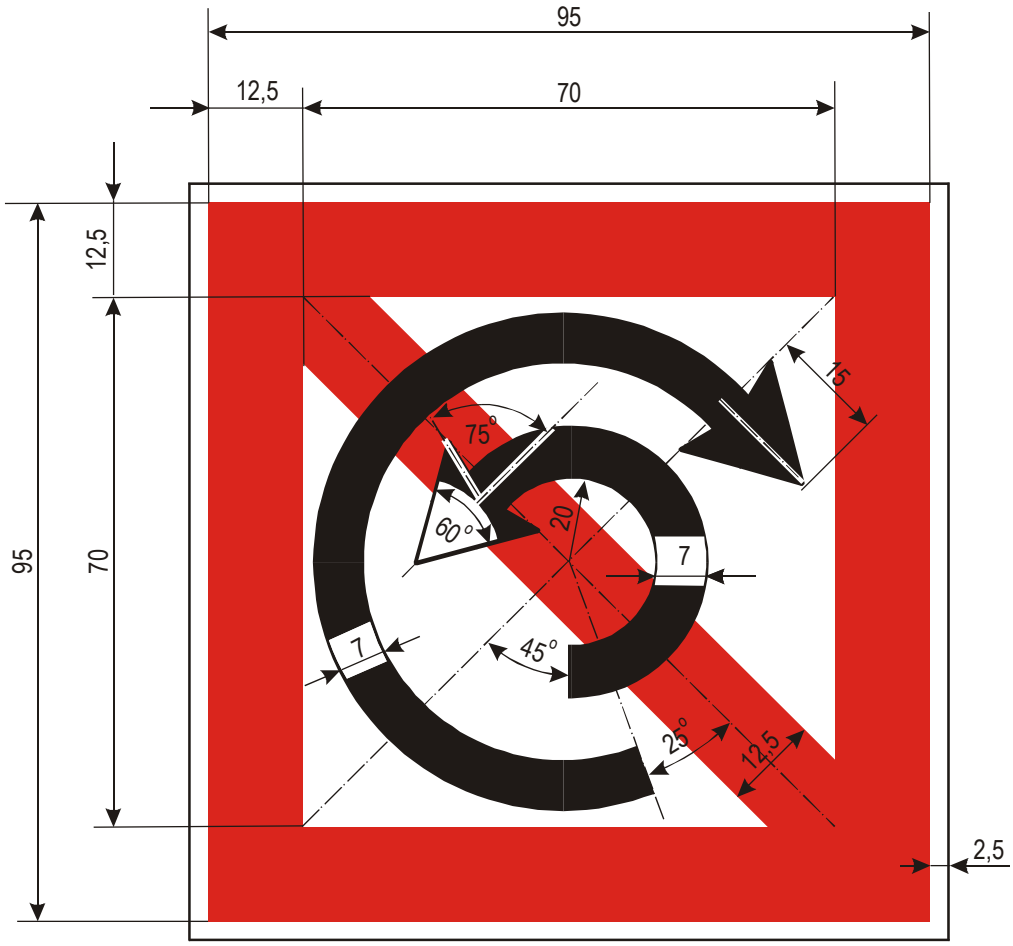
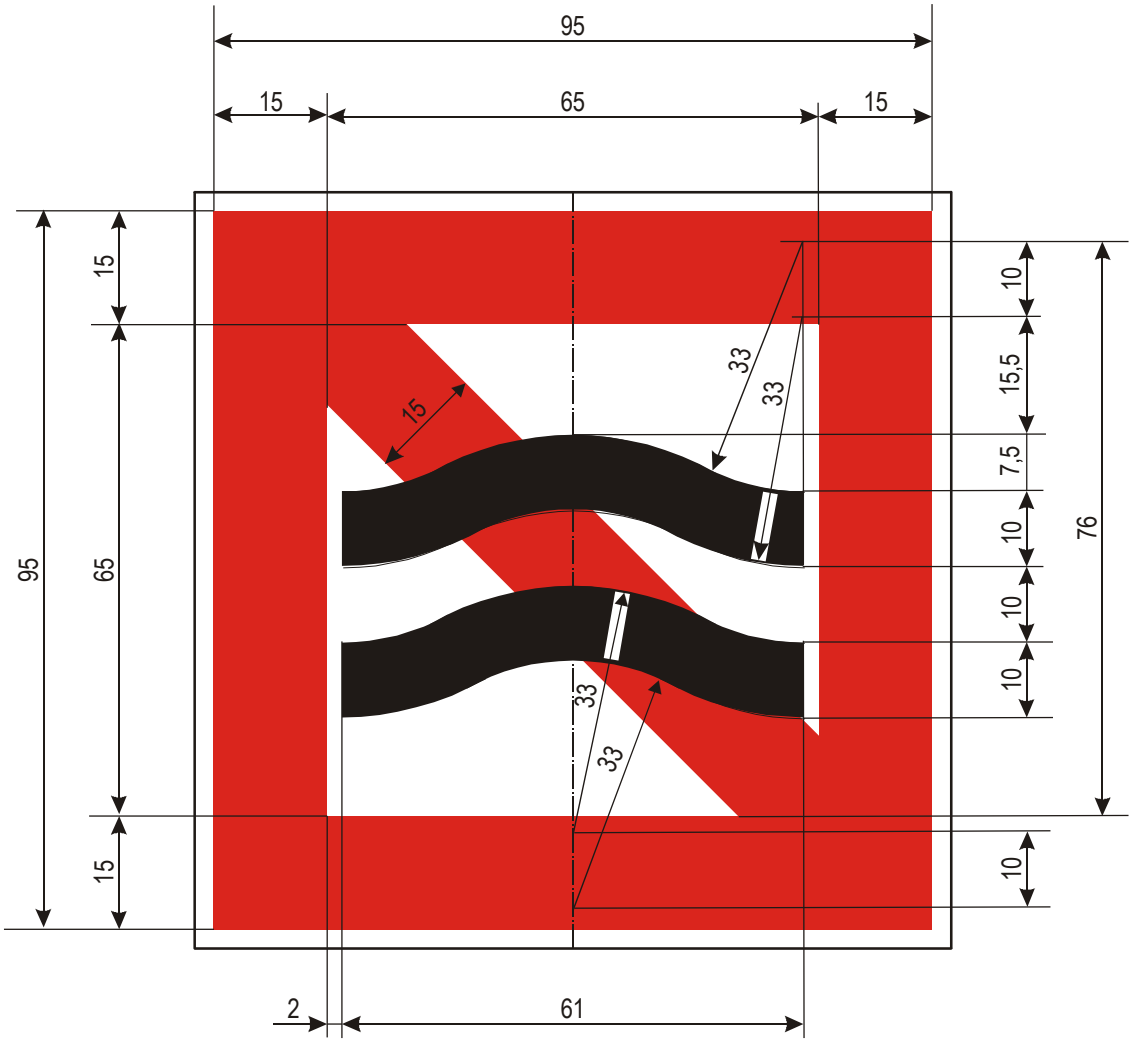
A. 8



A. 9a



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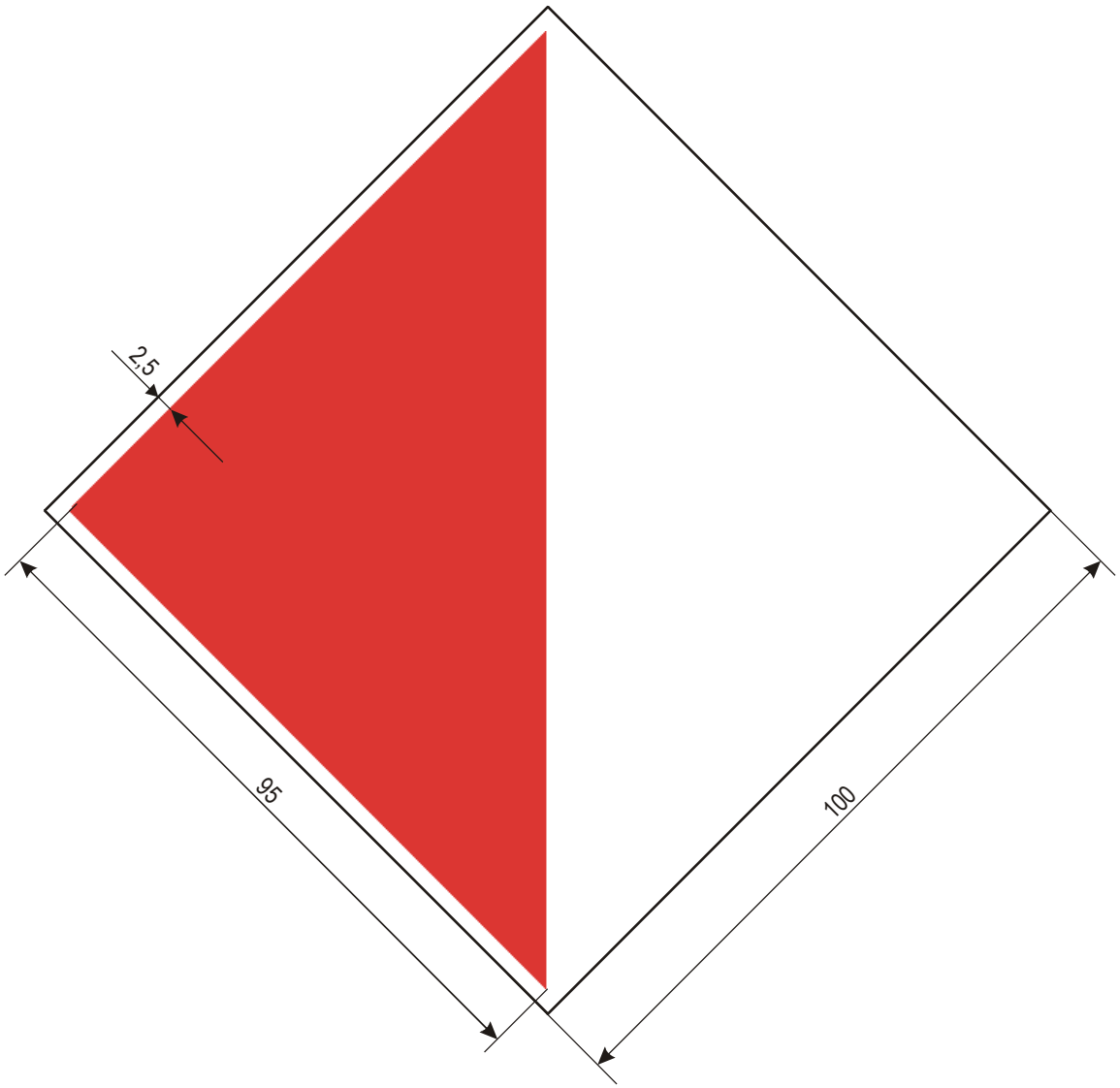
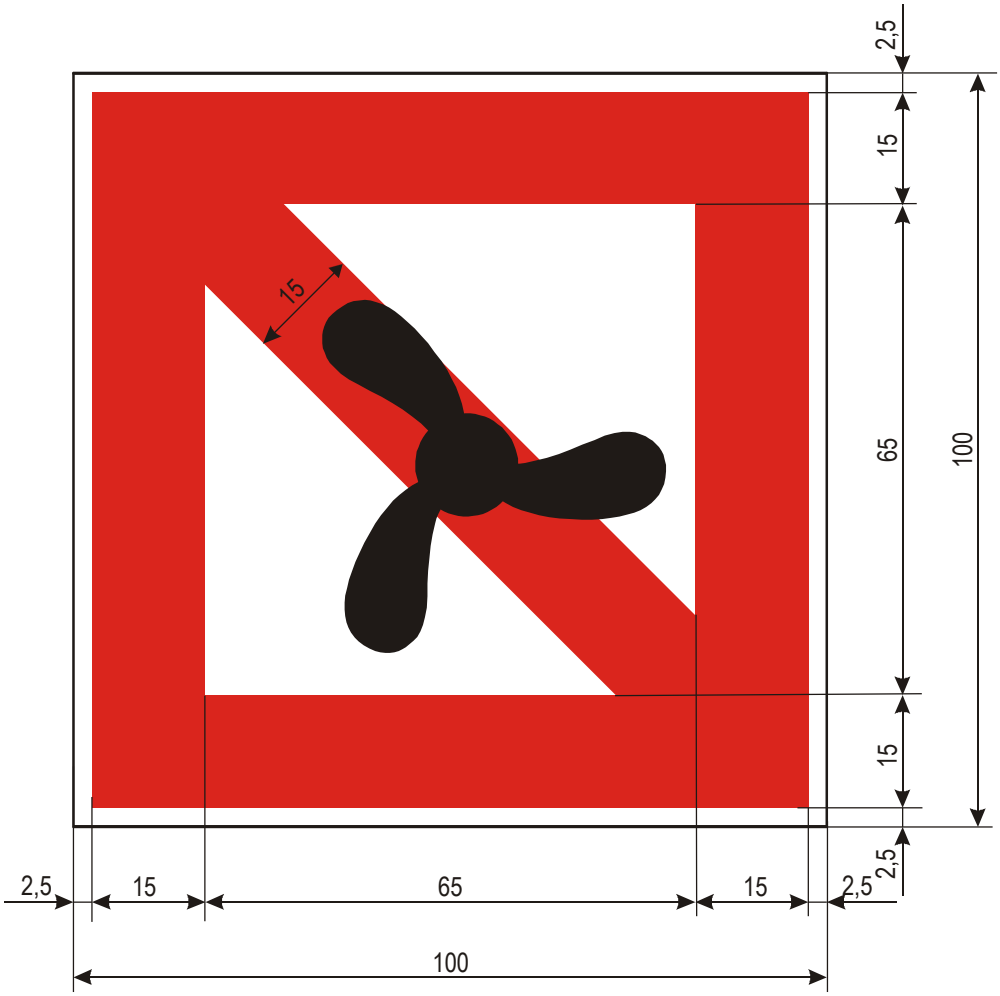
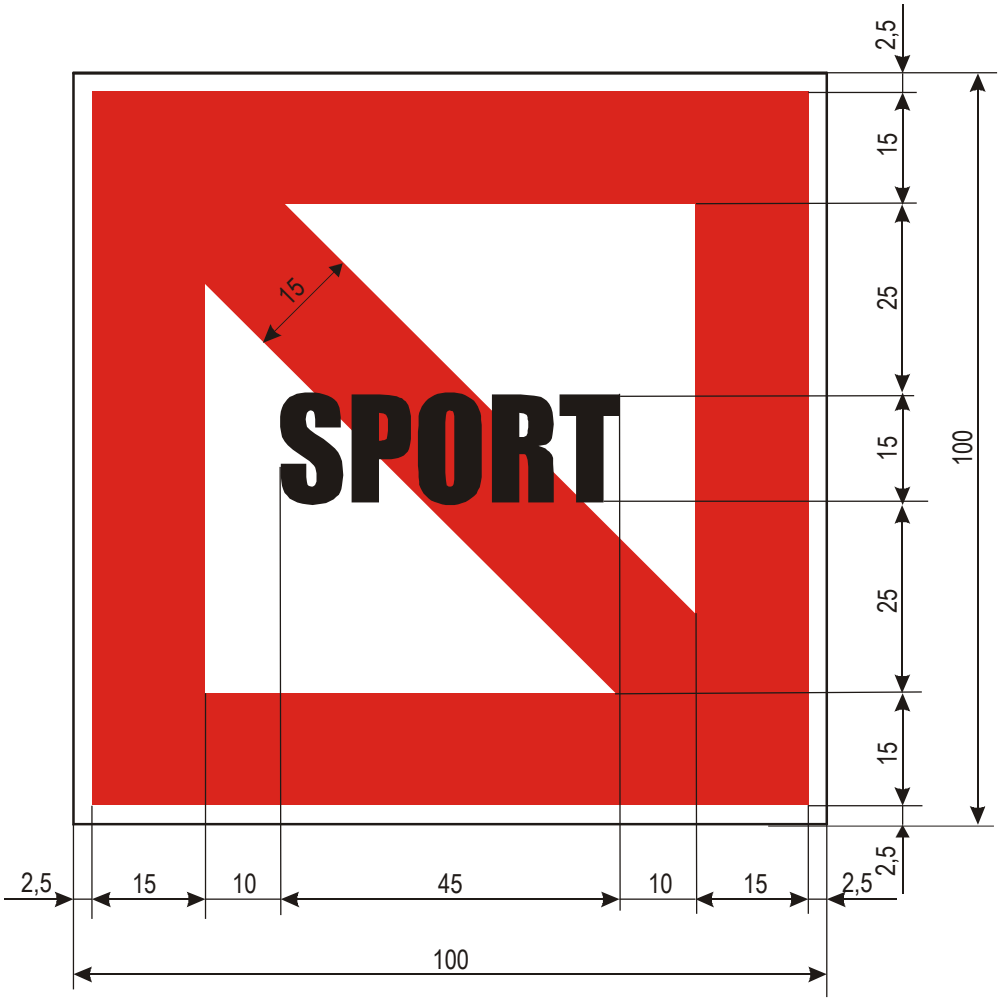


A. 12



A. 13



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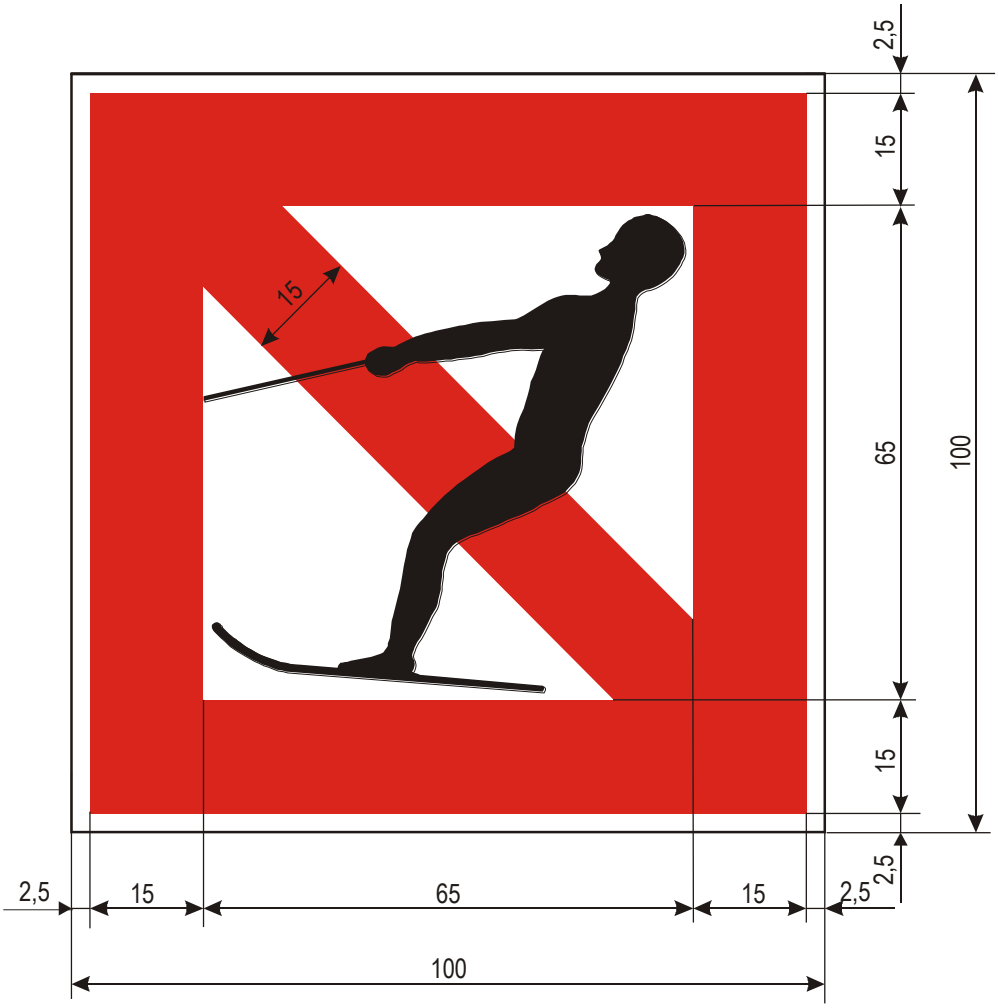

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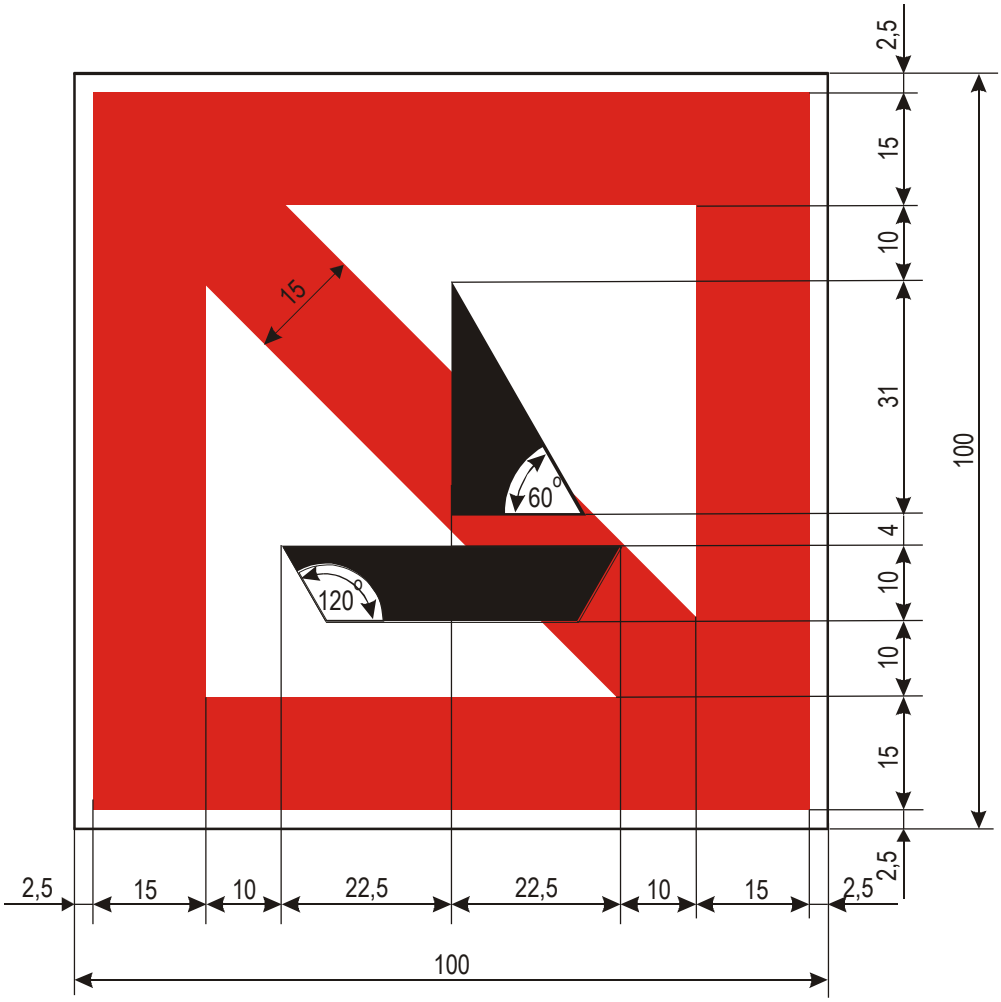

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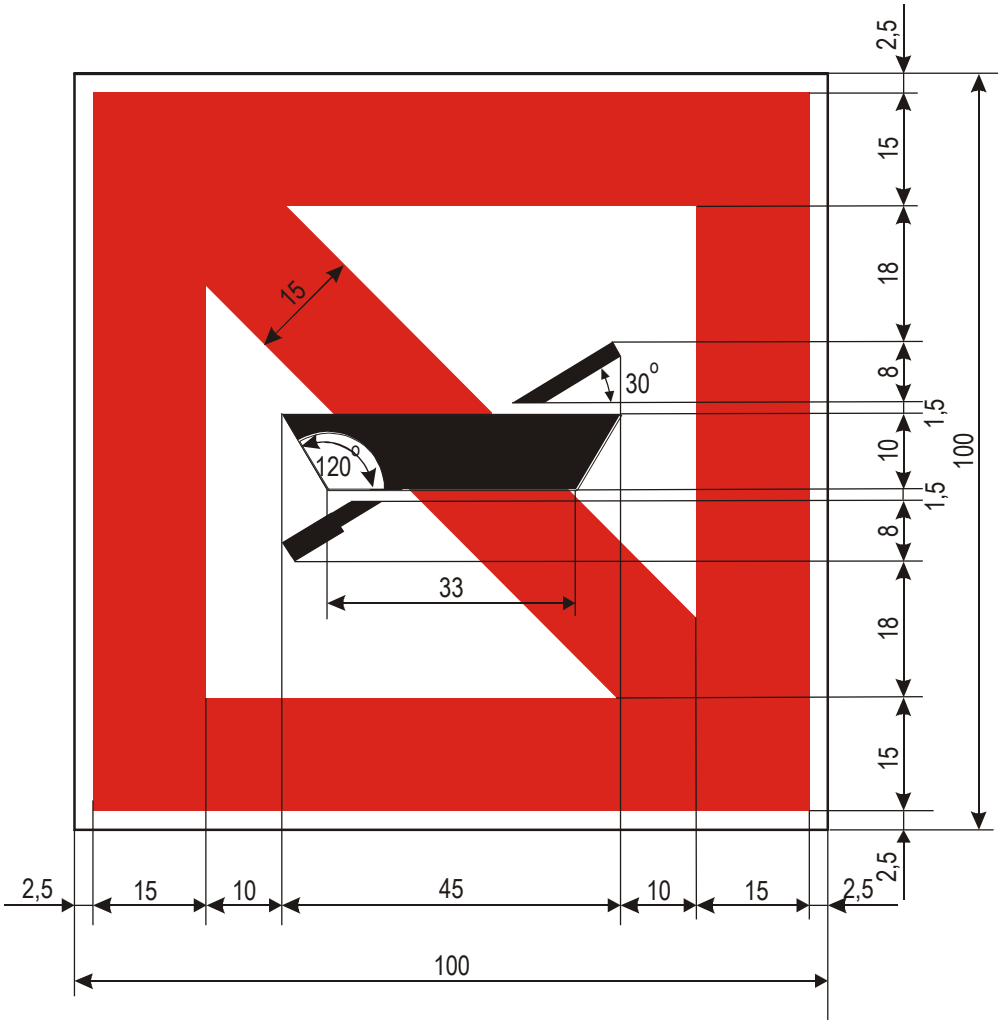

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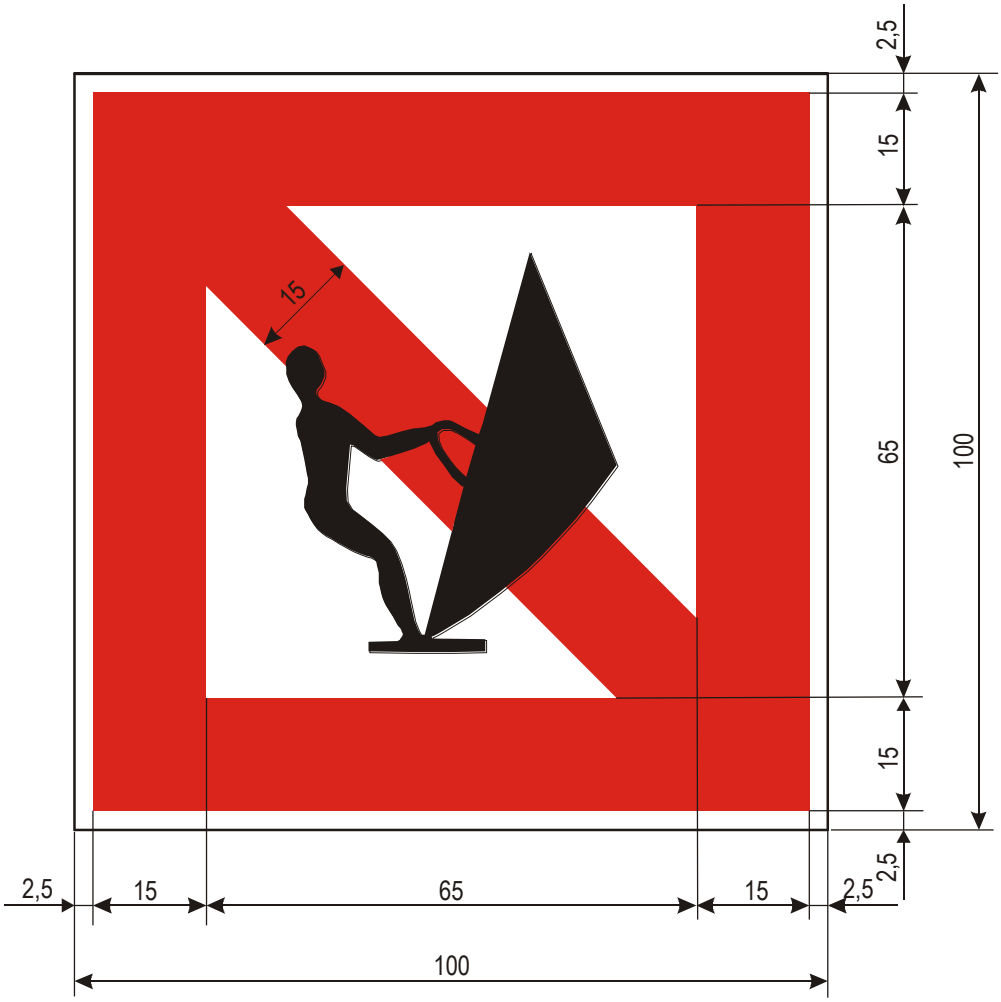

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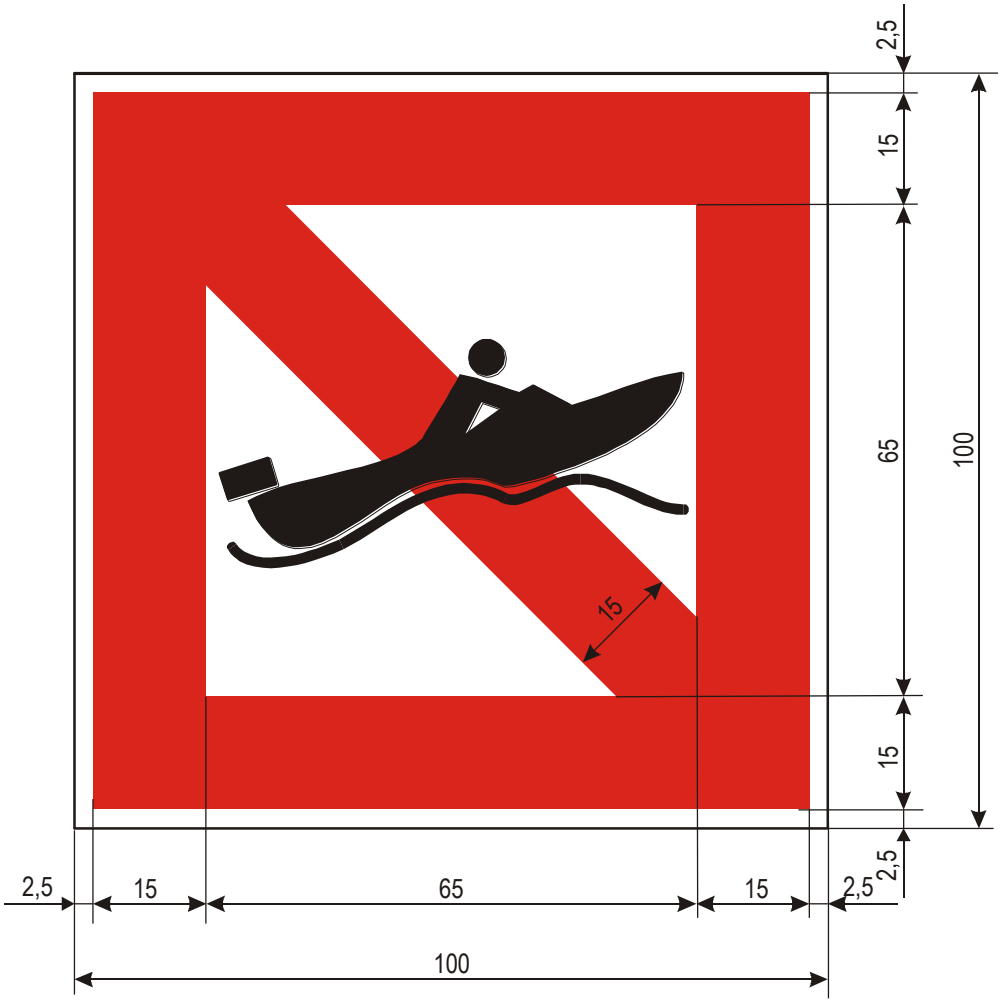

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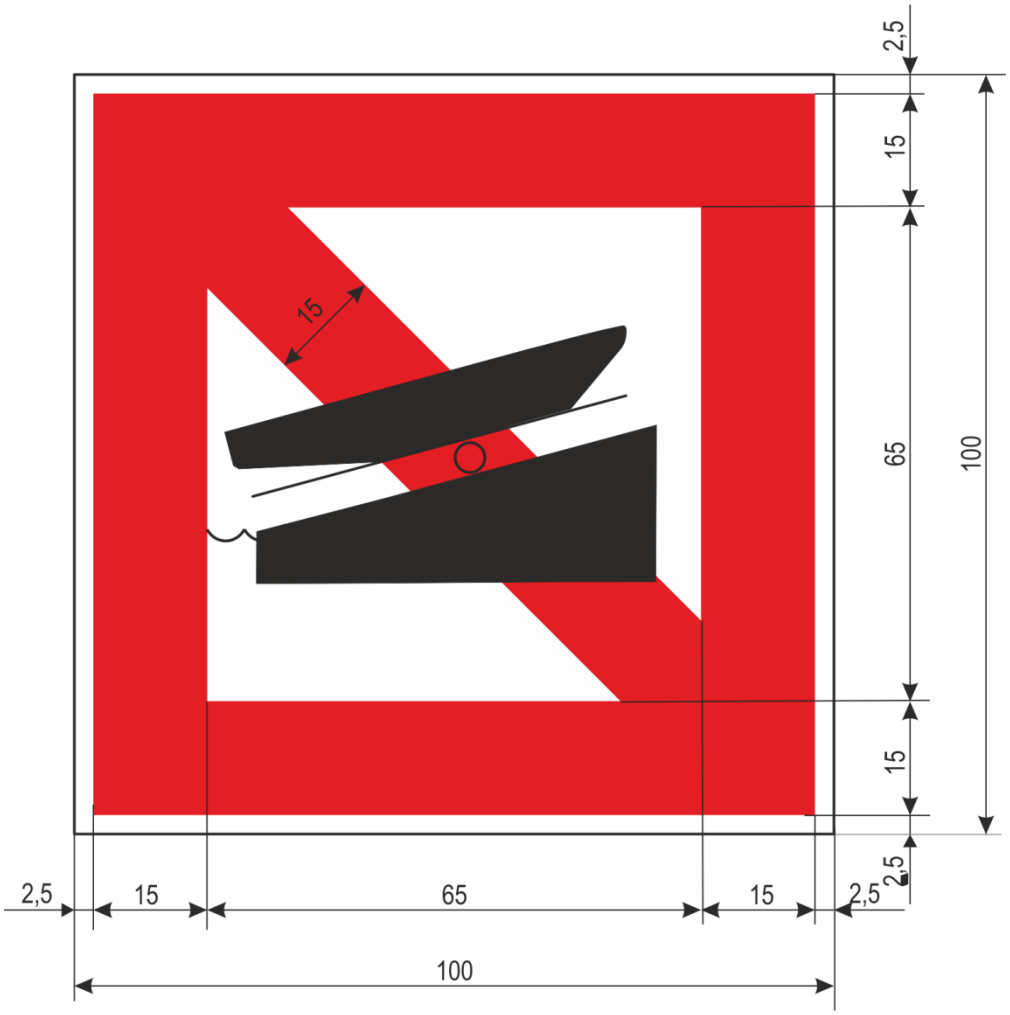

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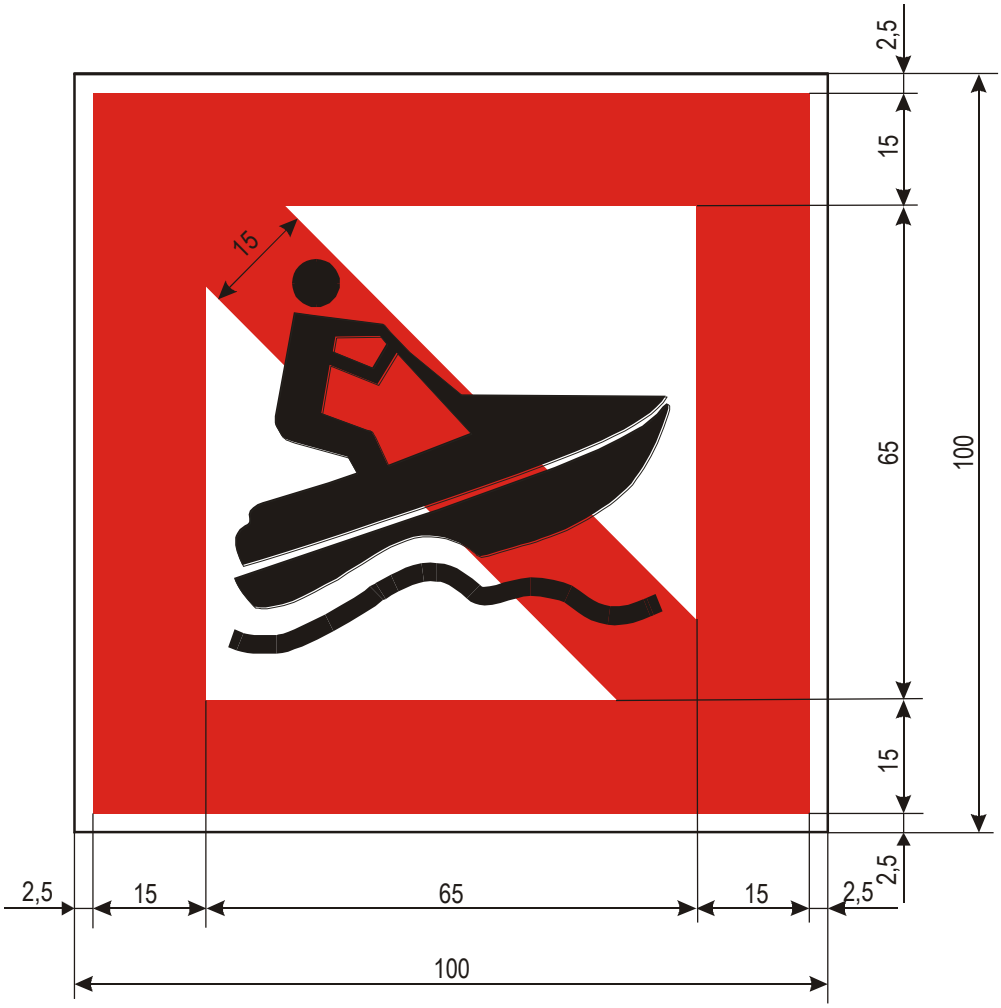
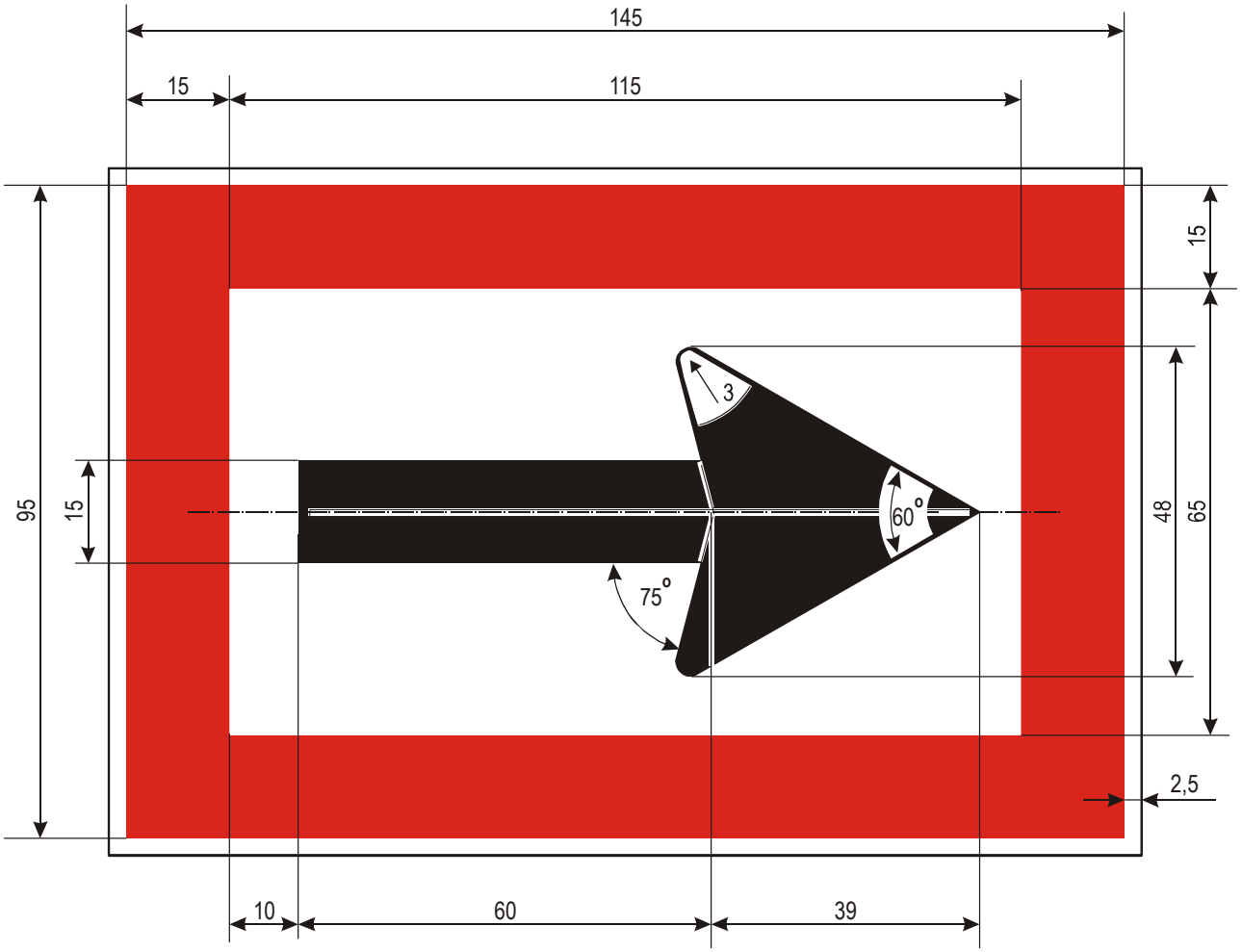


B. 1



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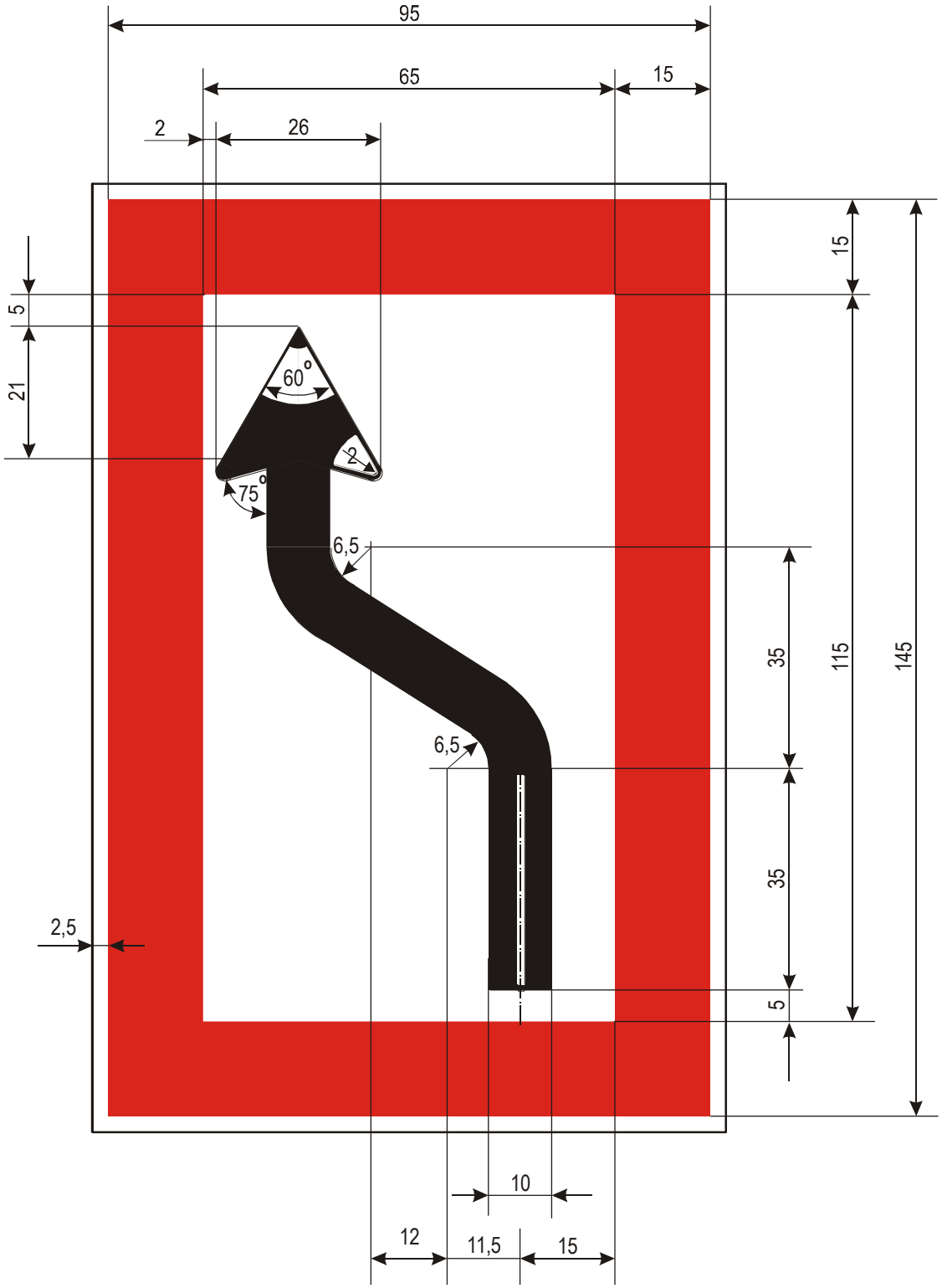
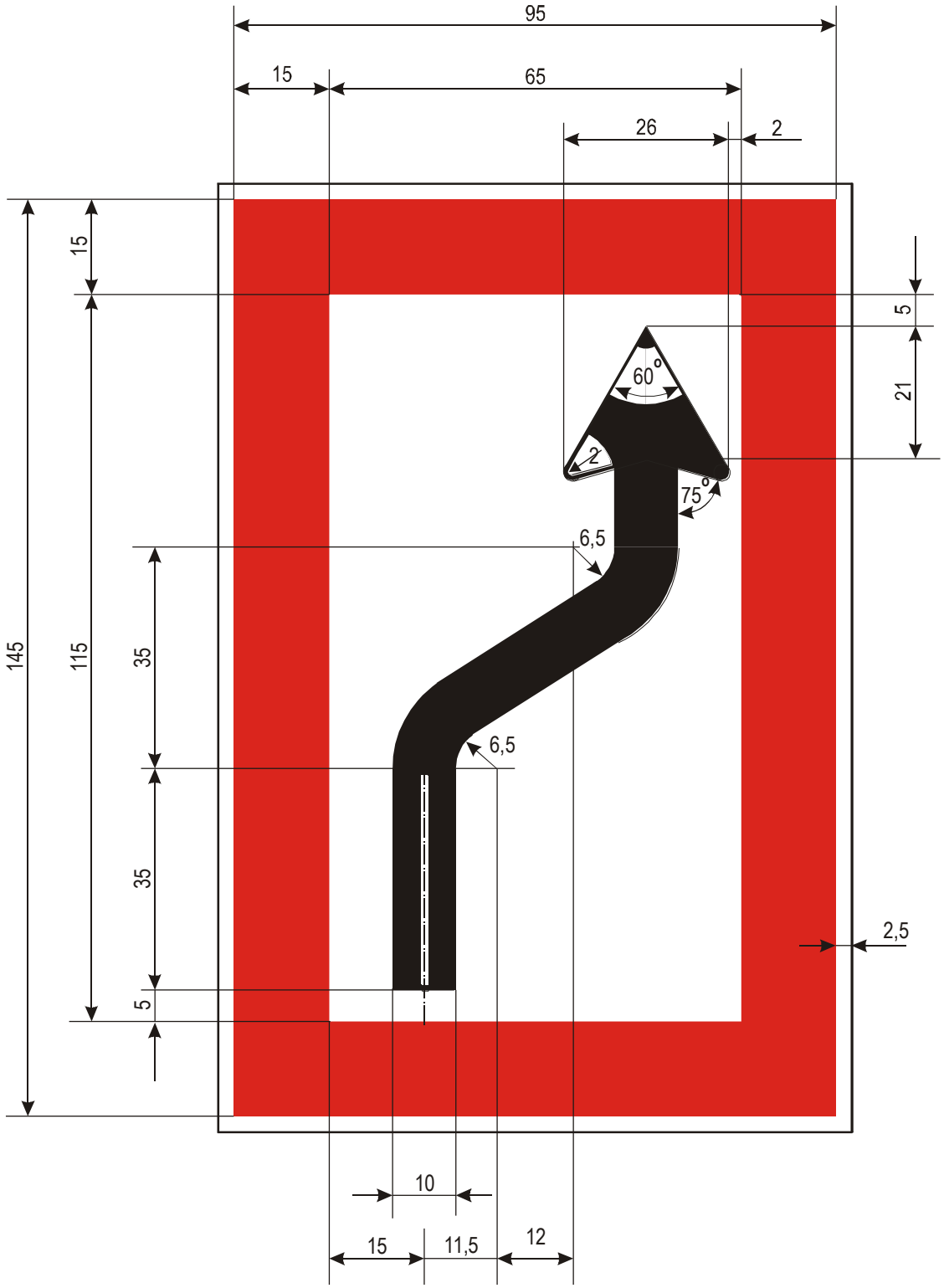


B. 2b



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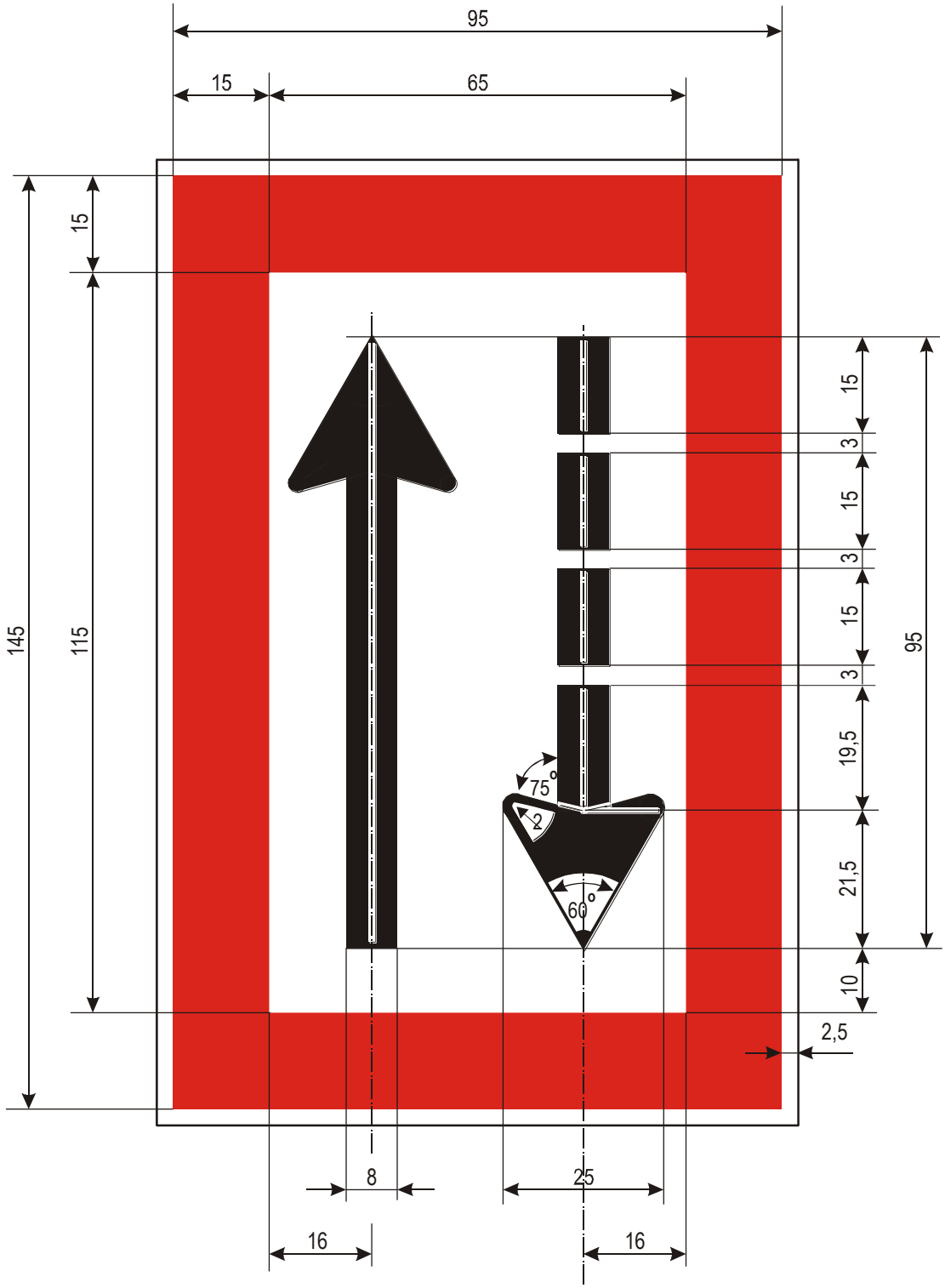

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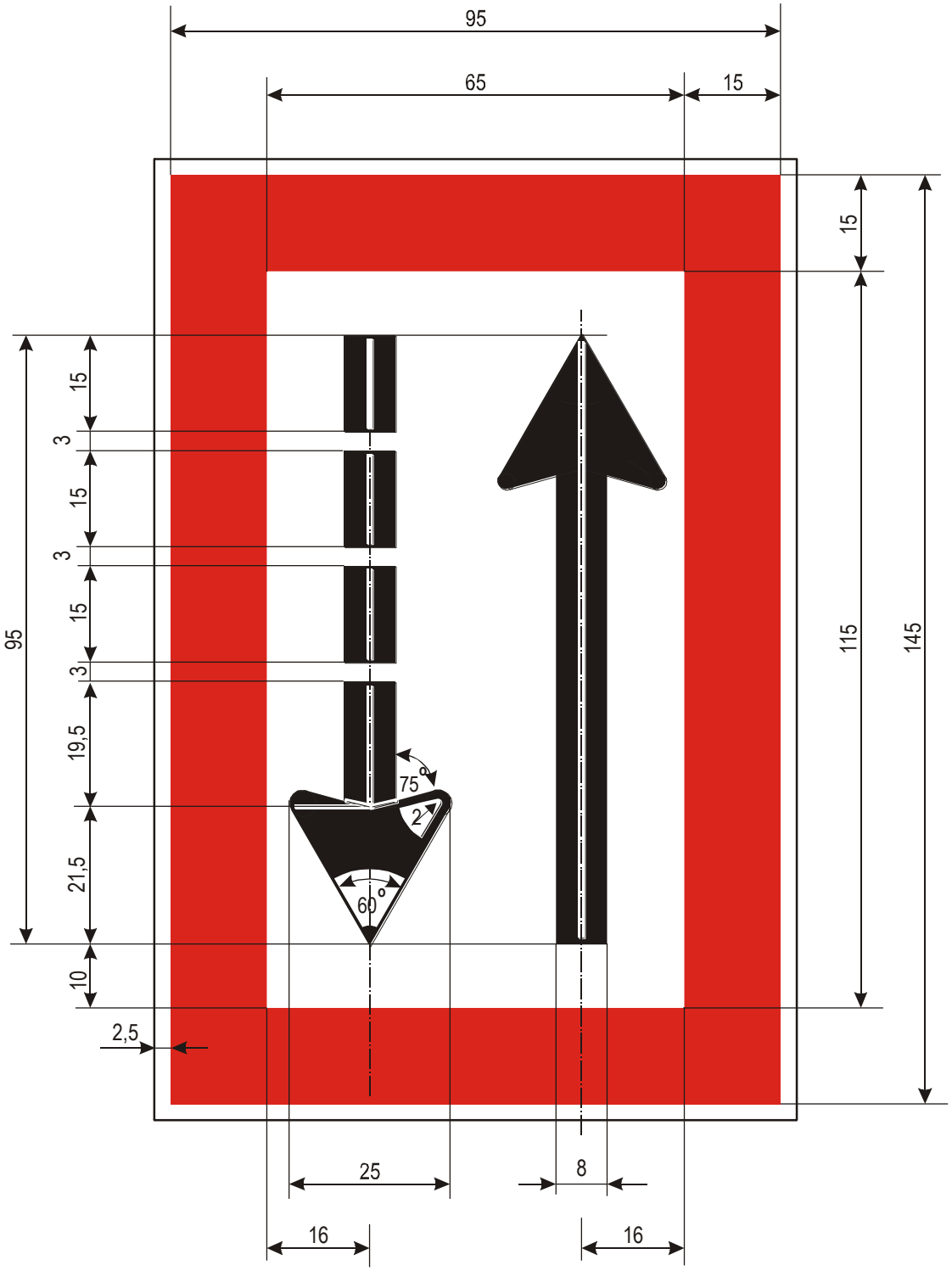

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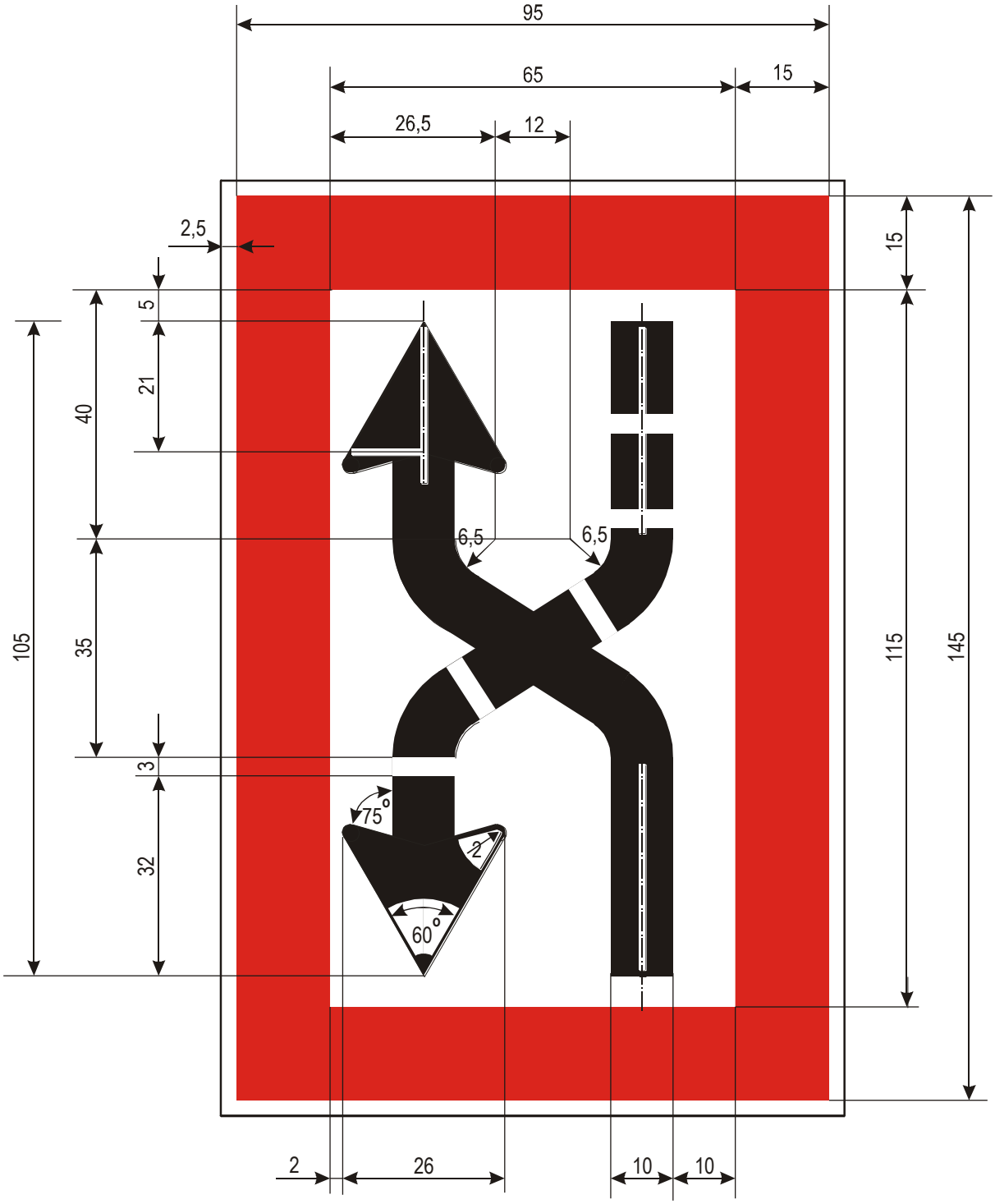
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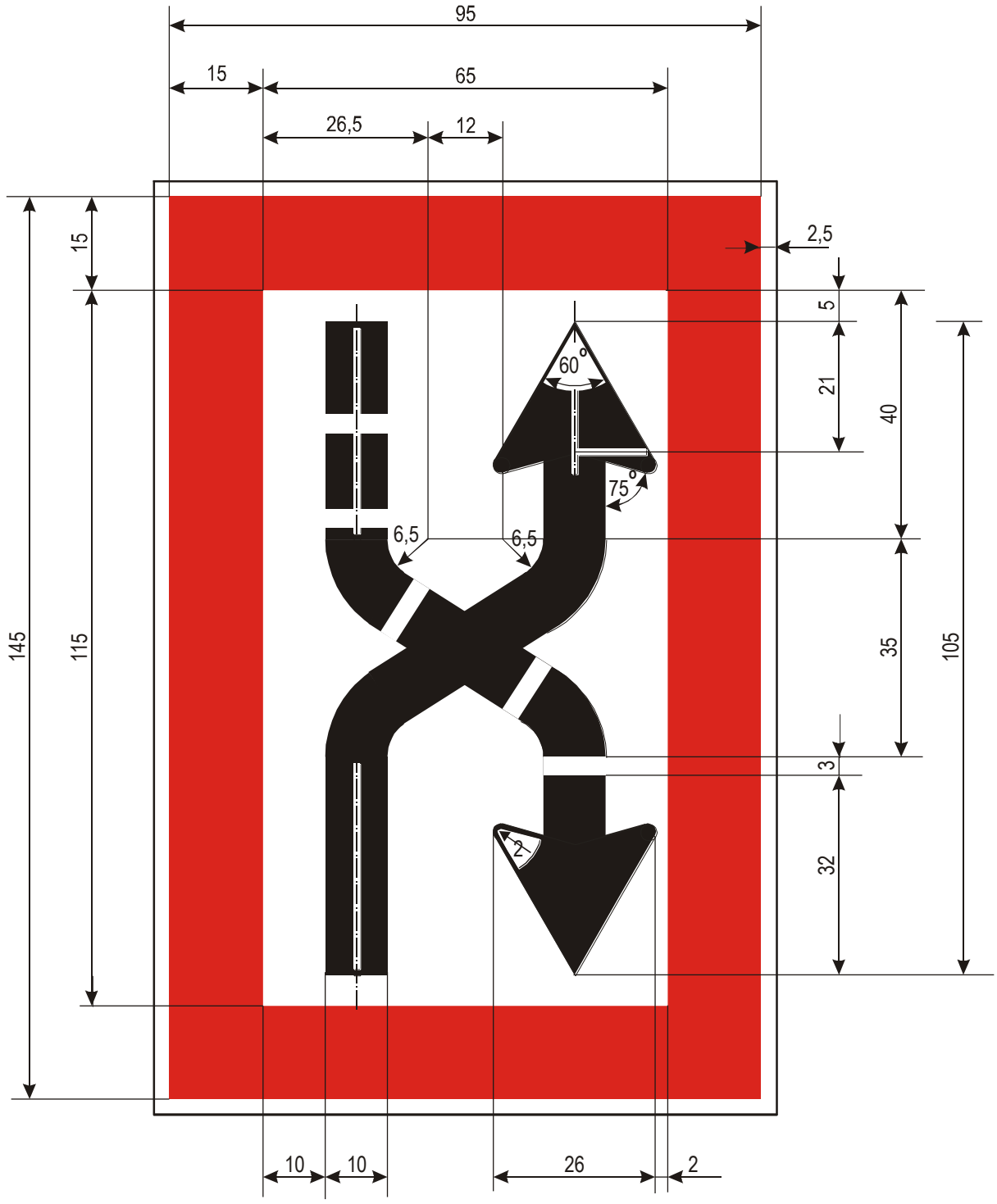
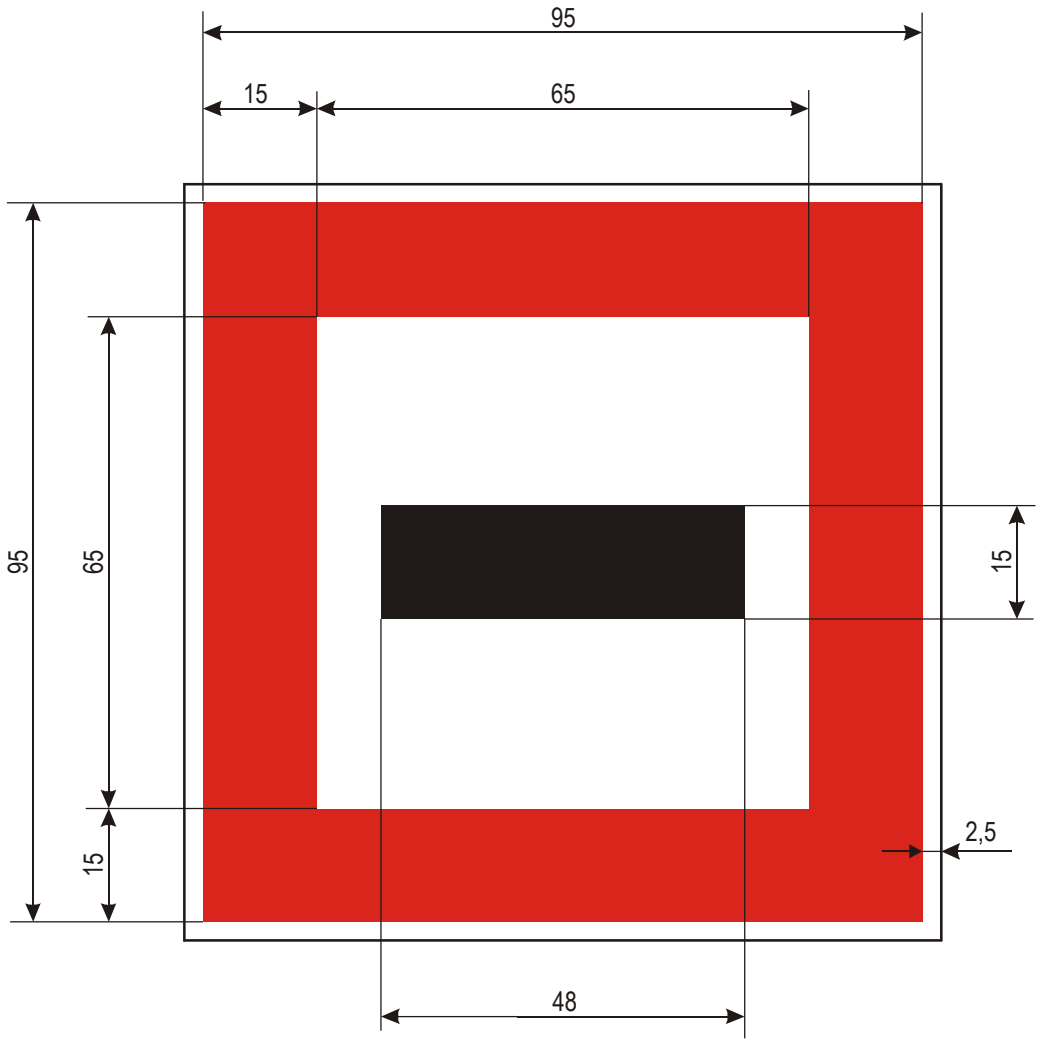
B. 4b



B. 5



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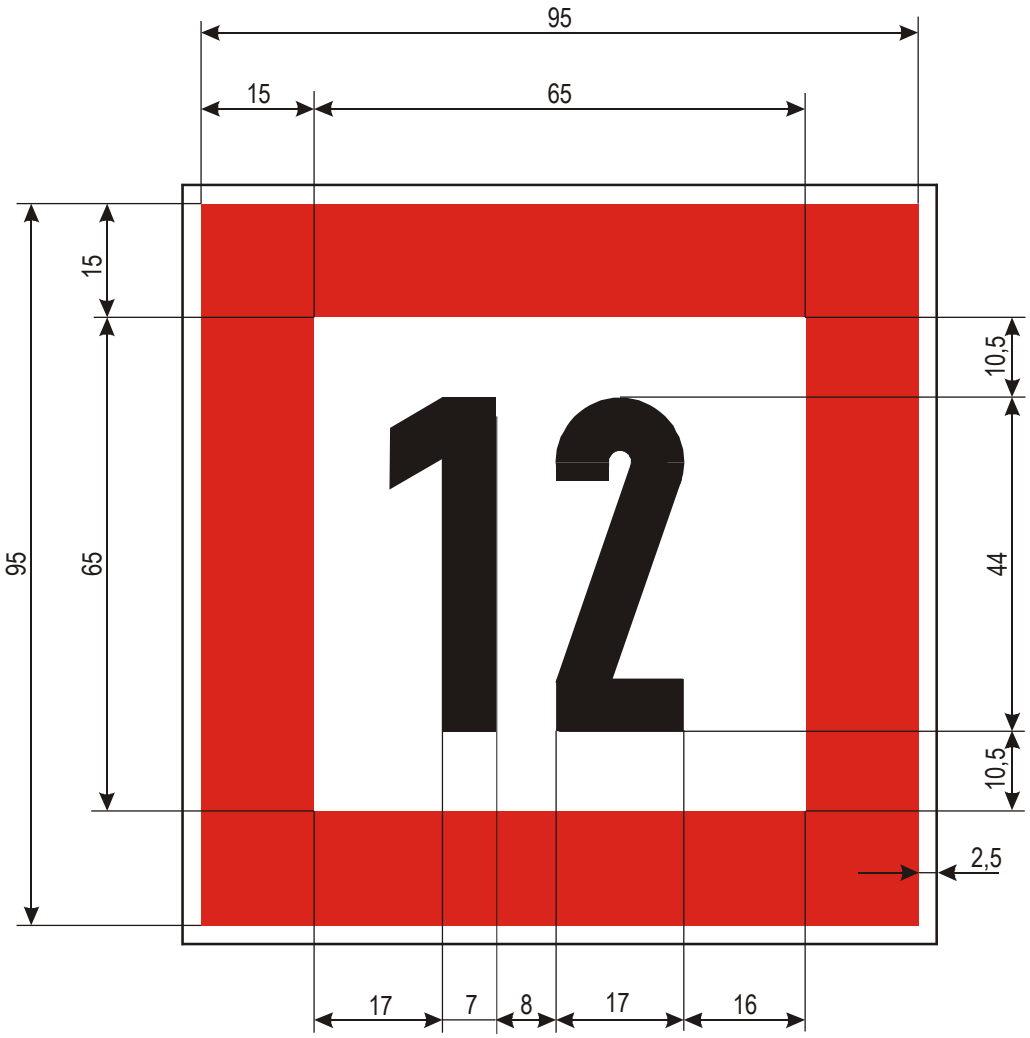

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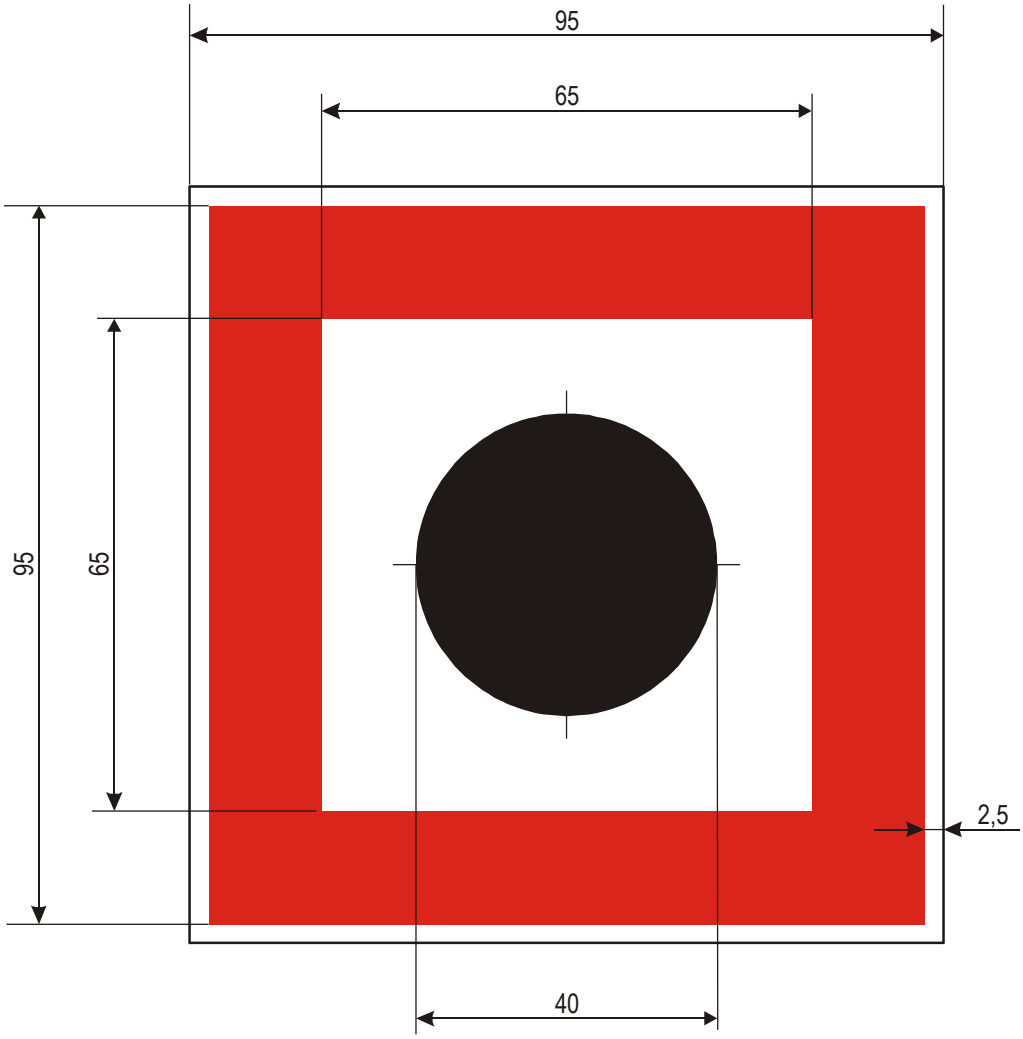

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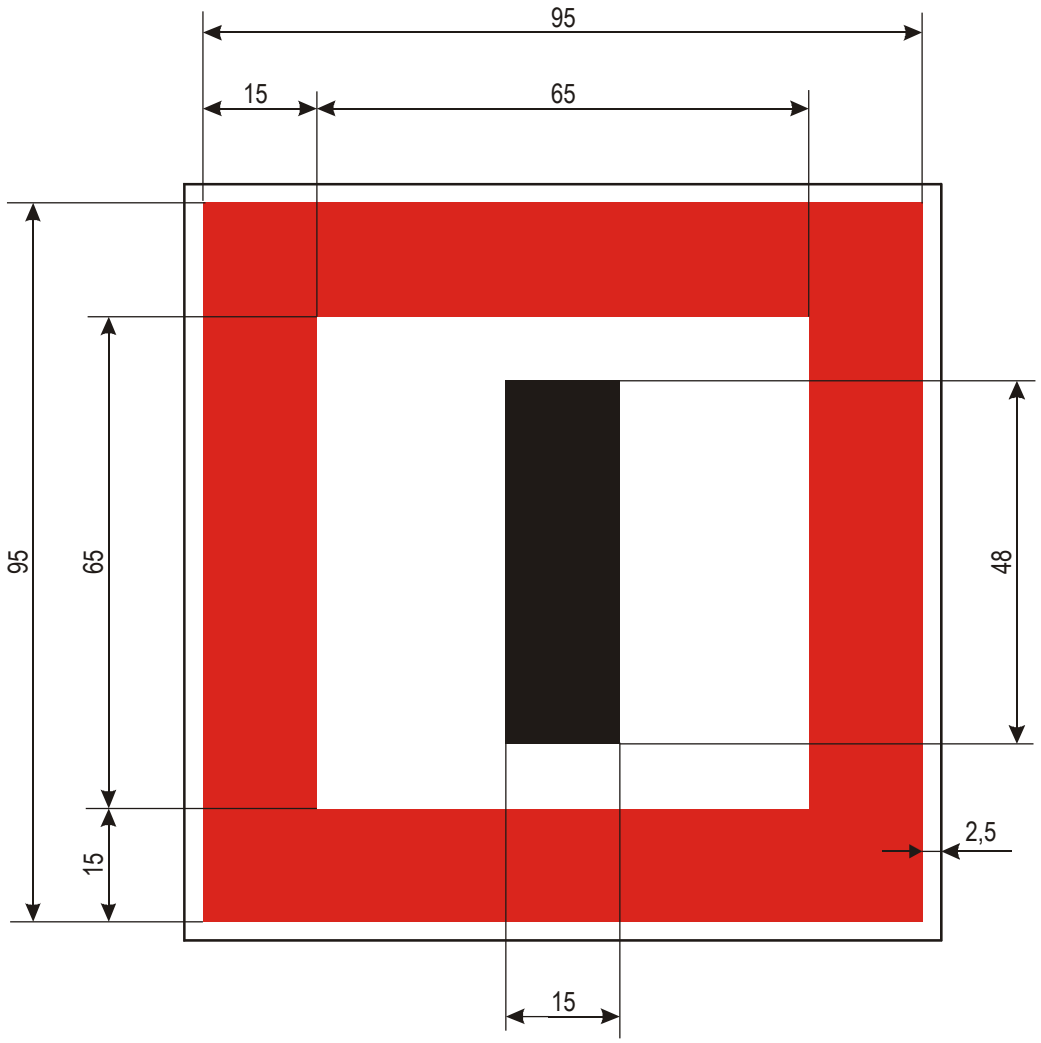

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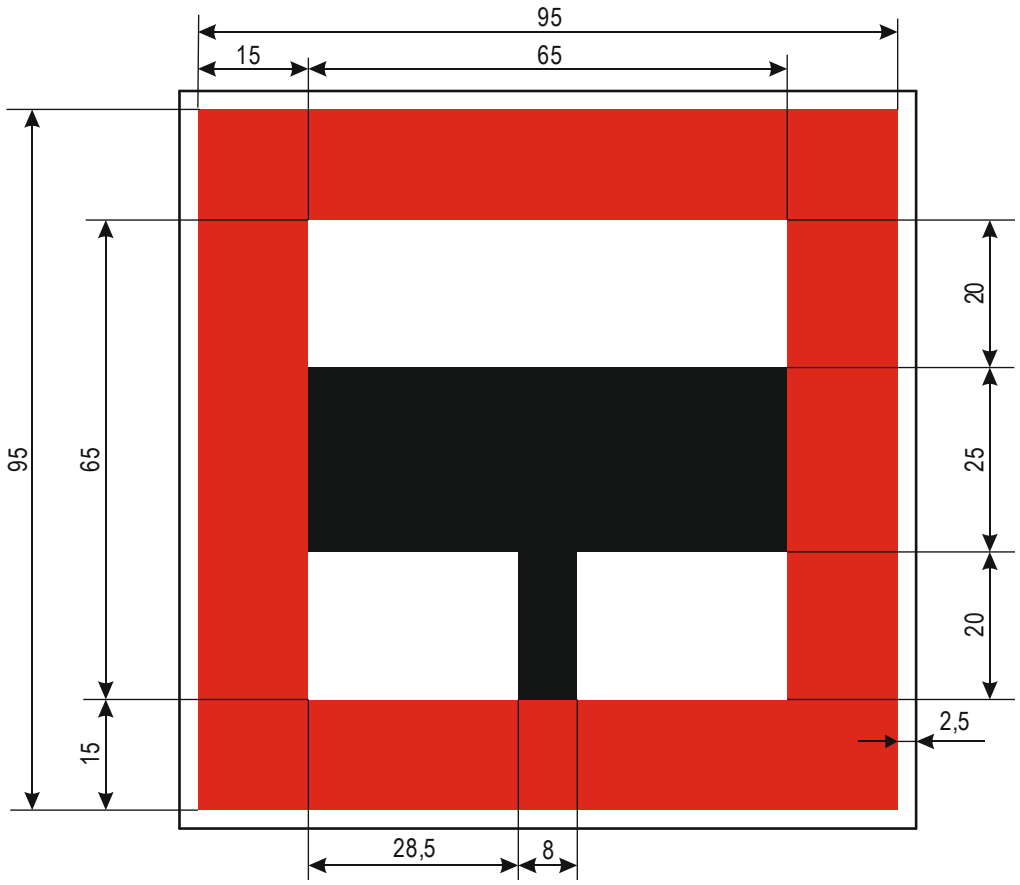

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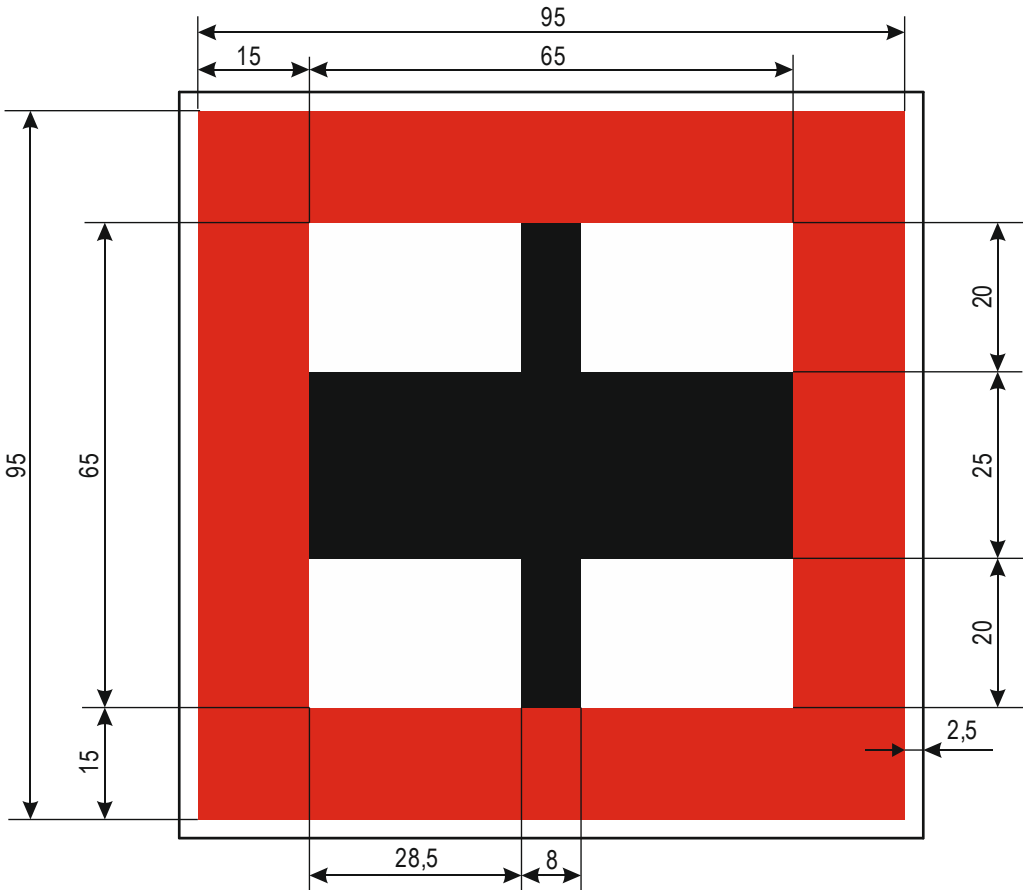

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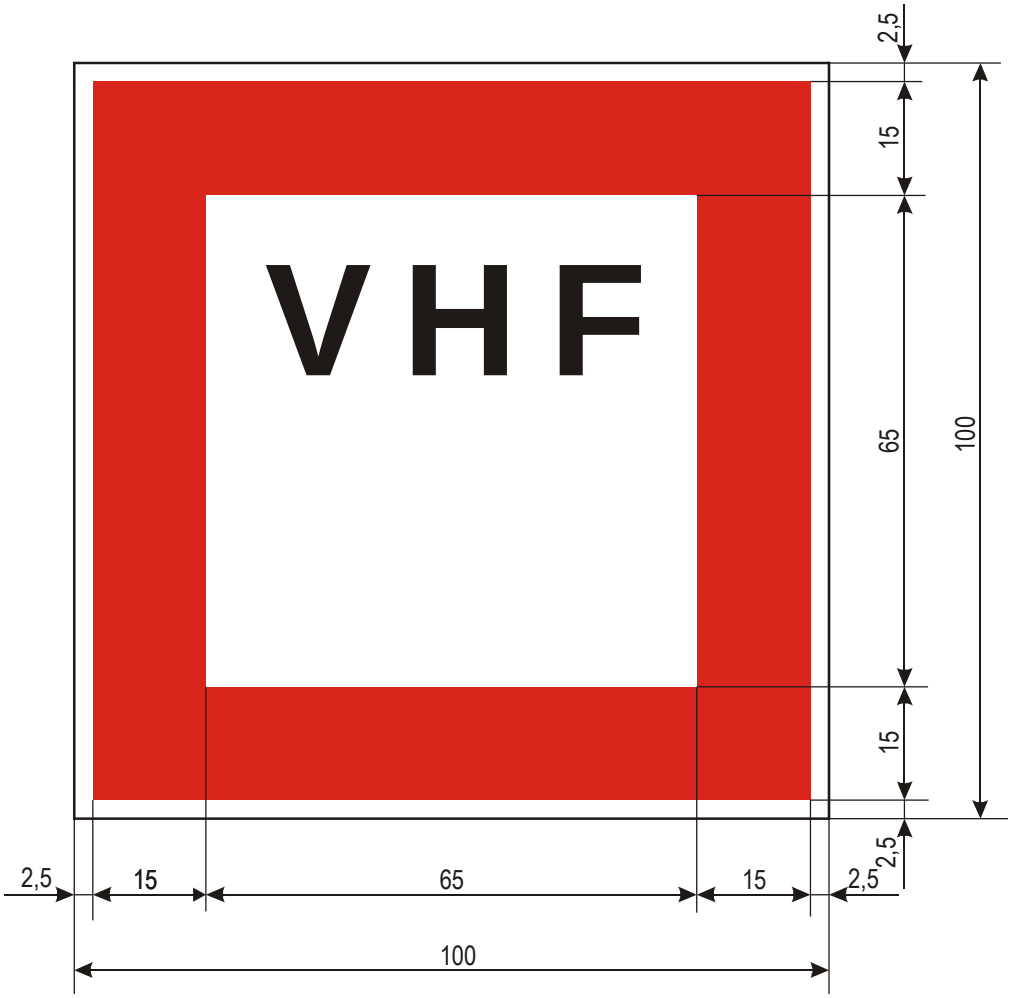

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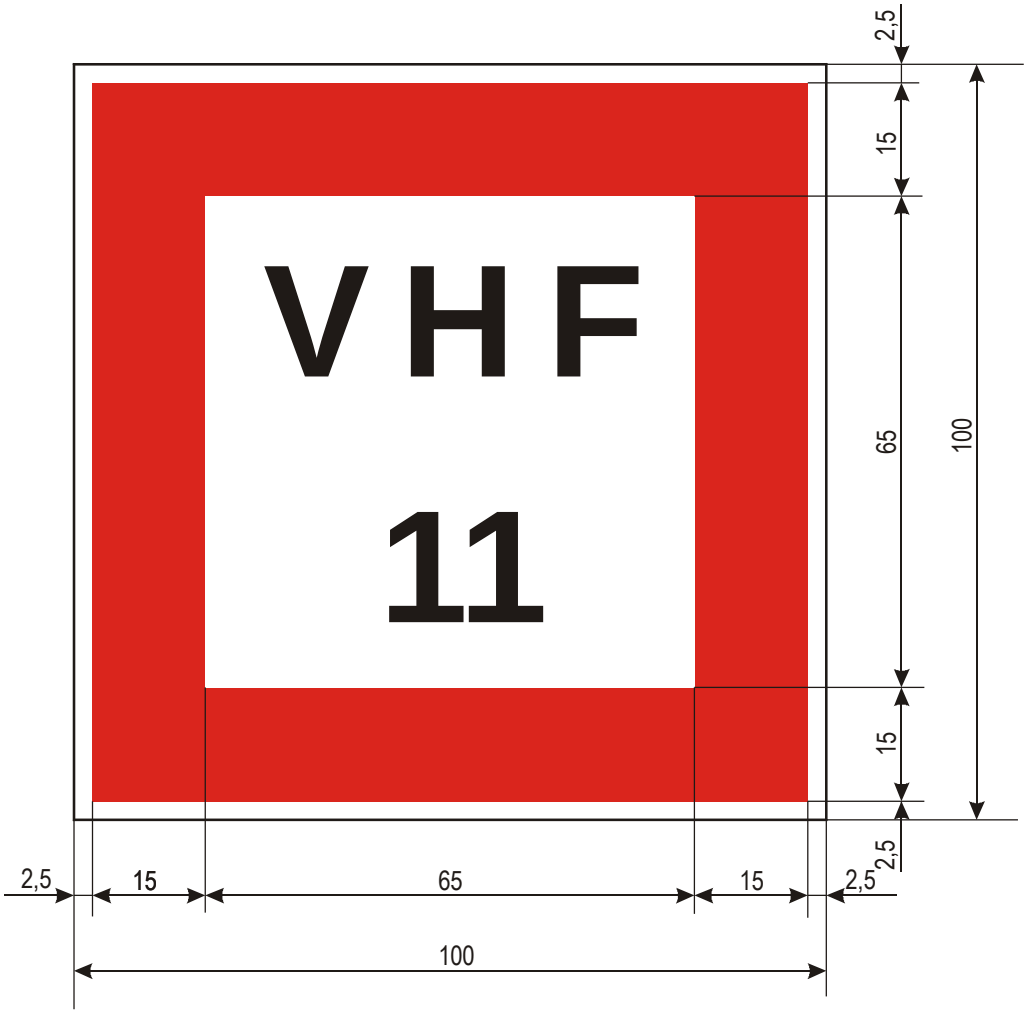

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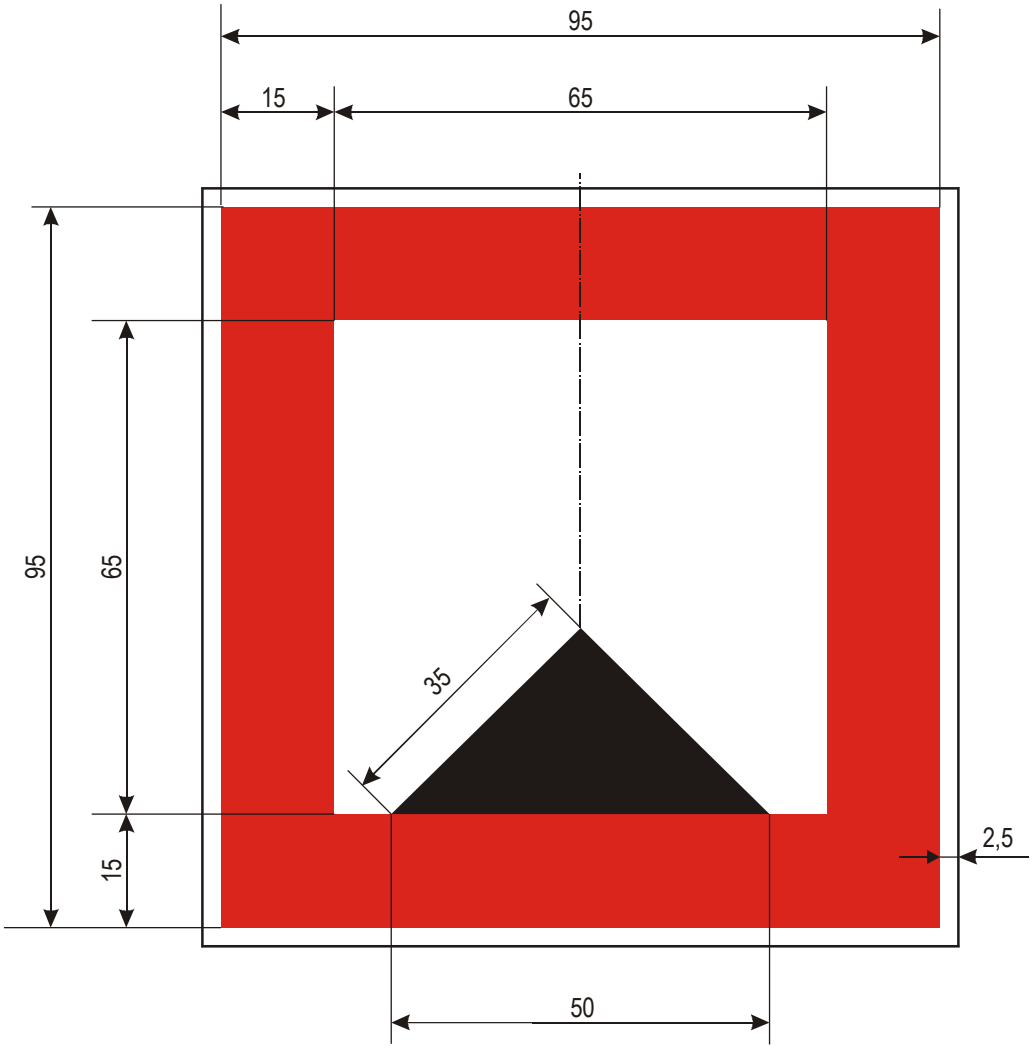

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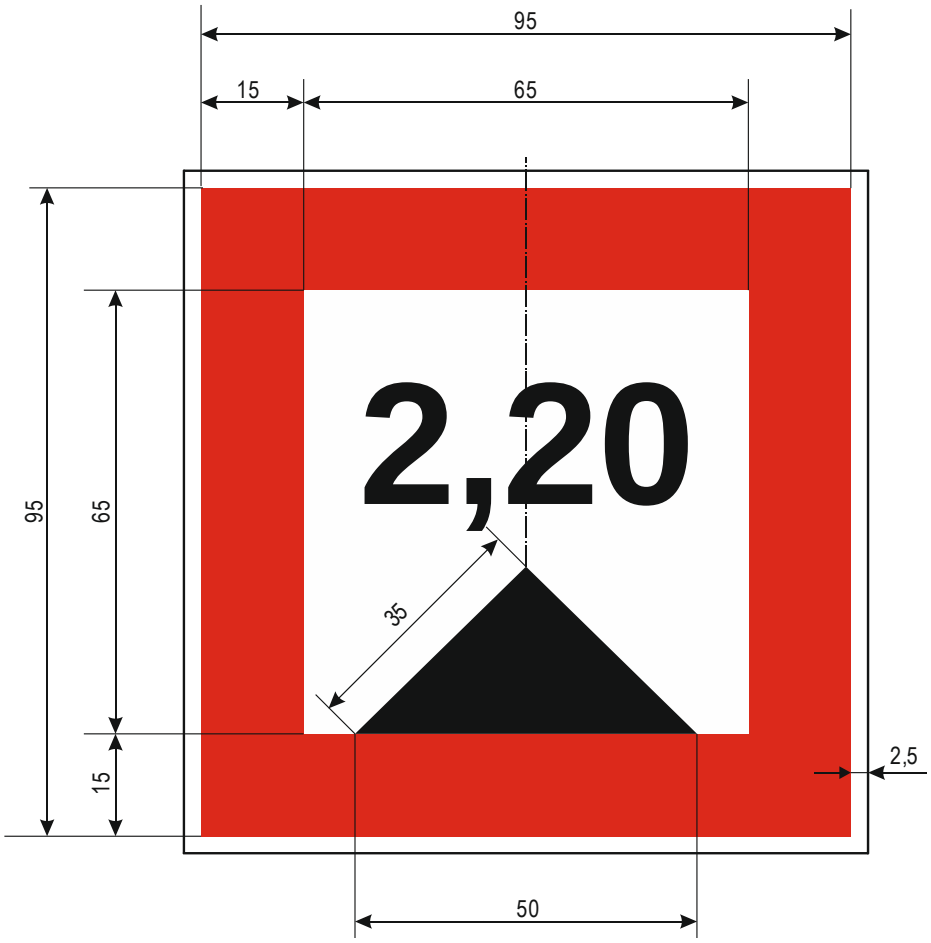

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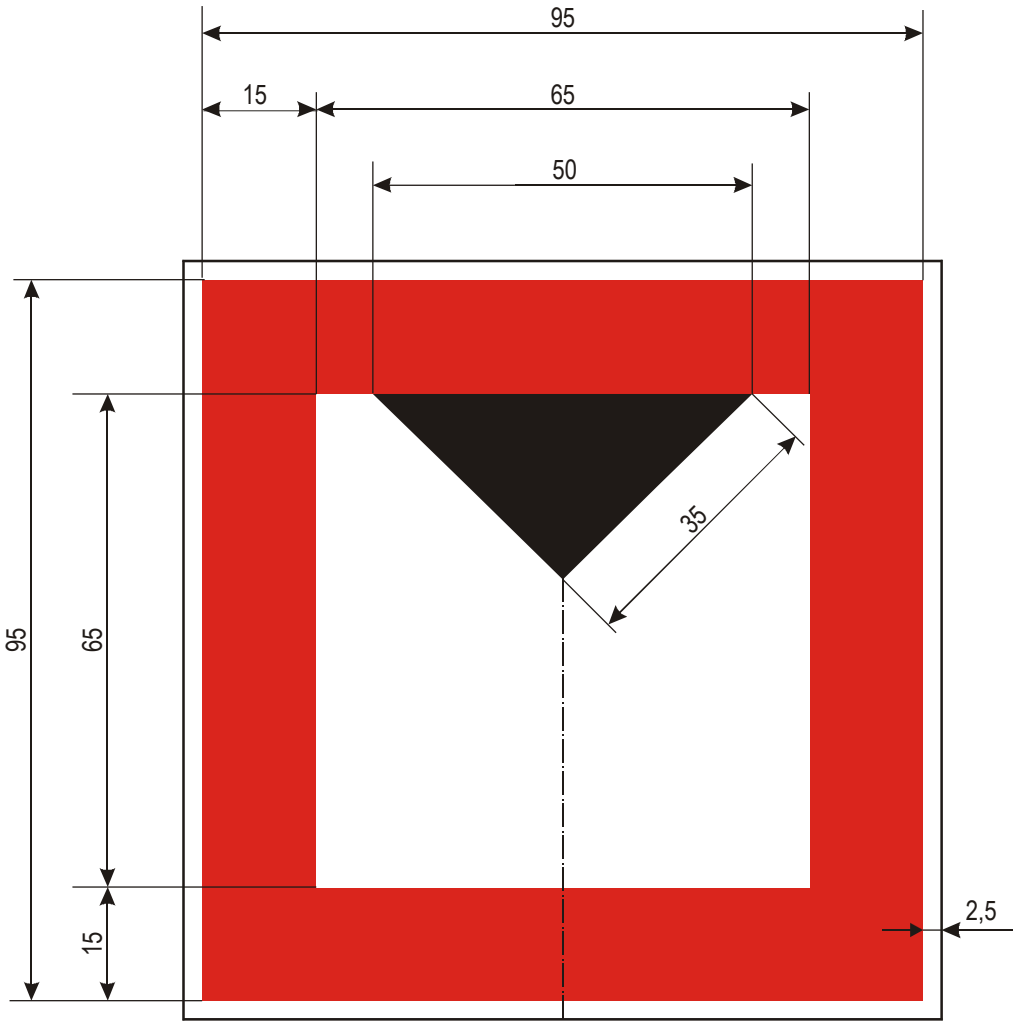

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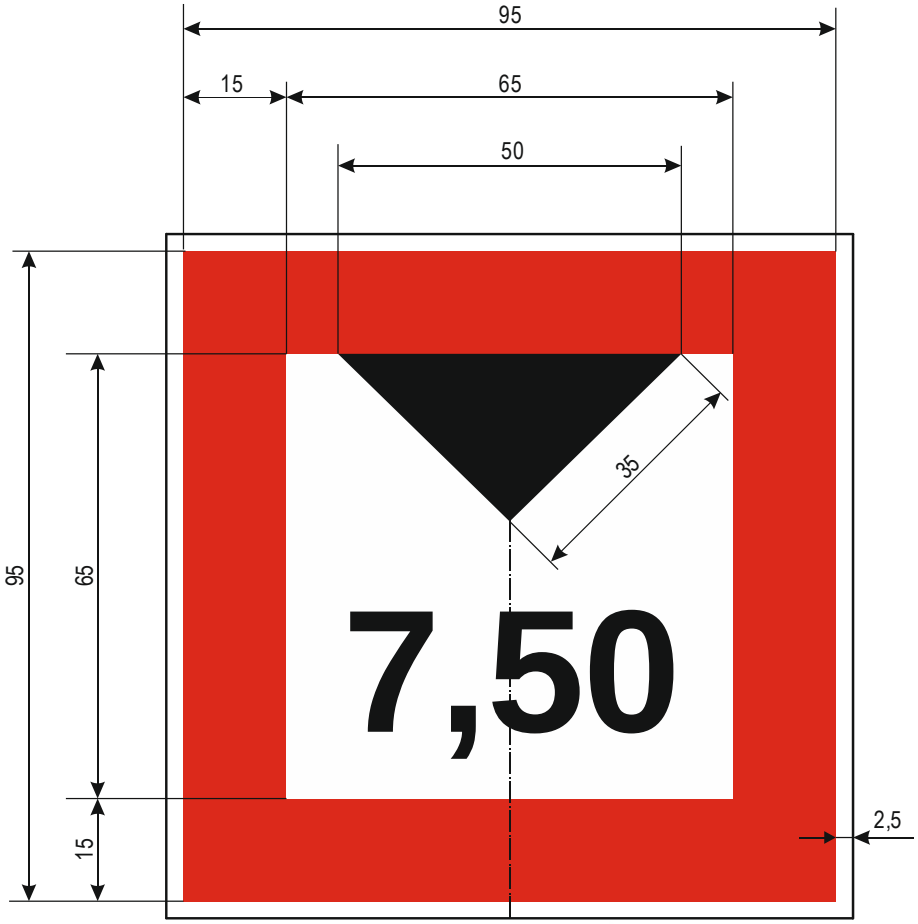

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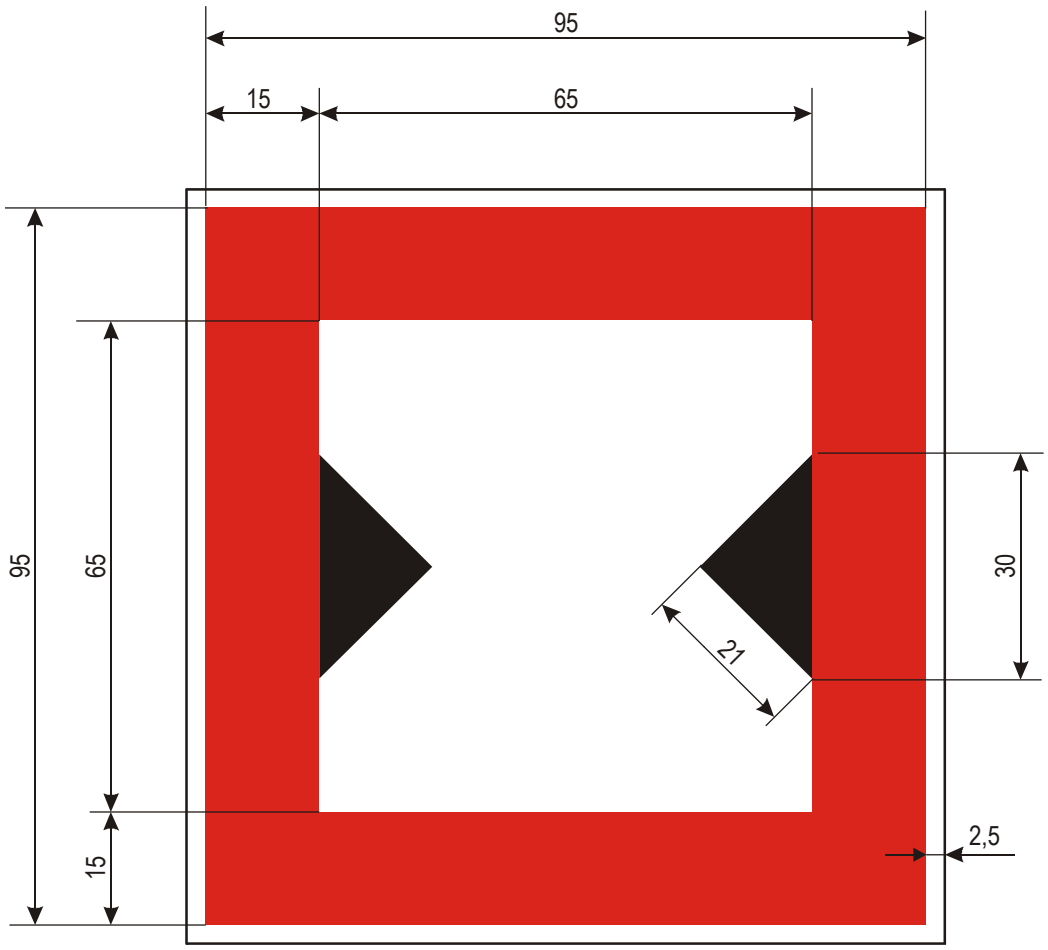

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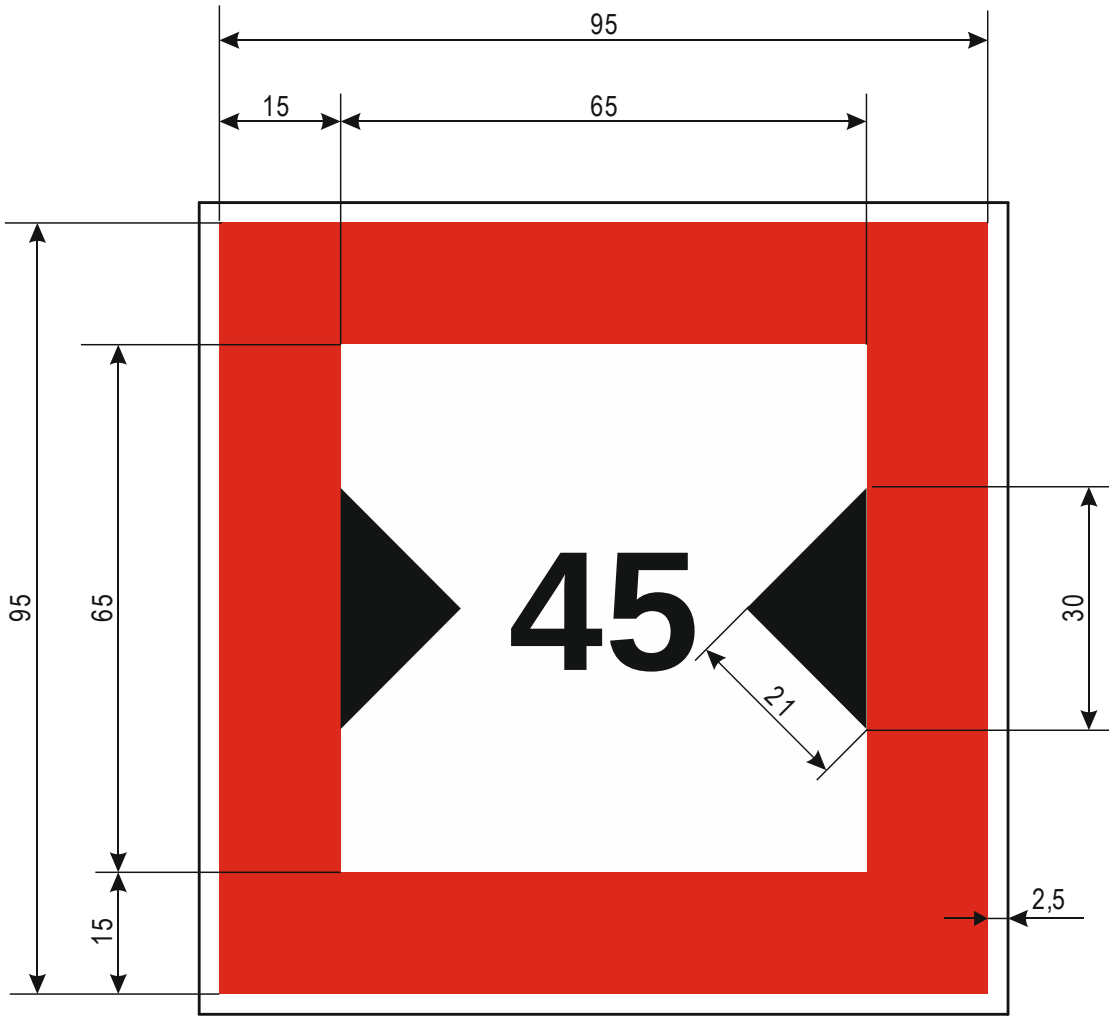

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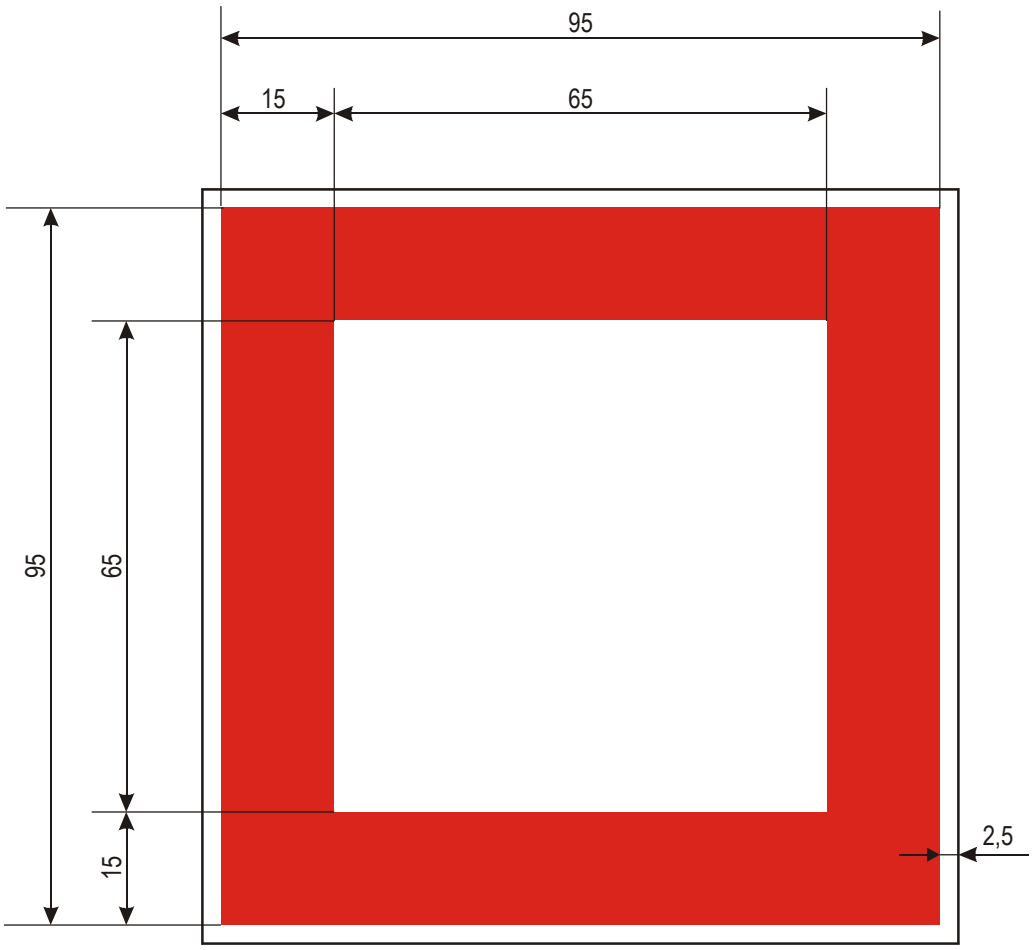

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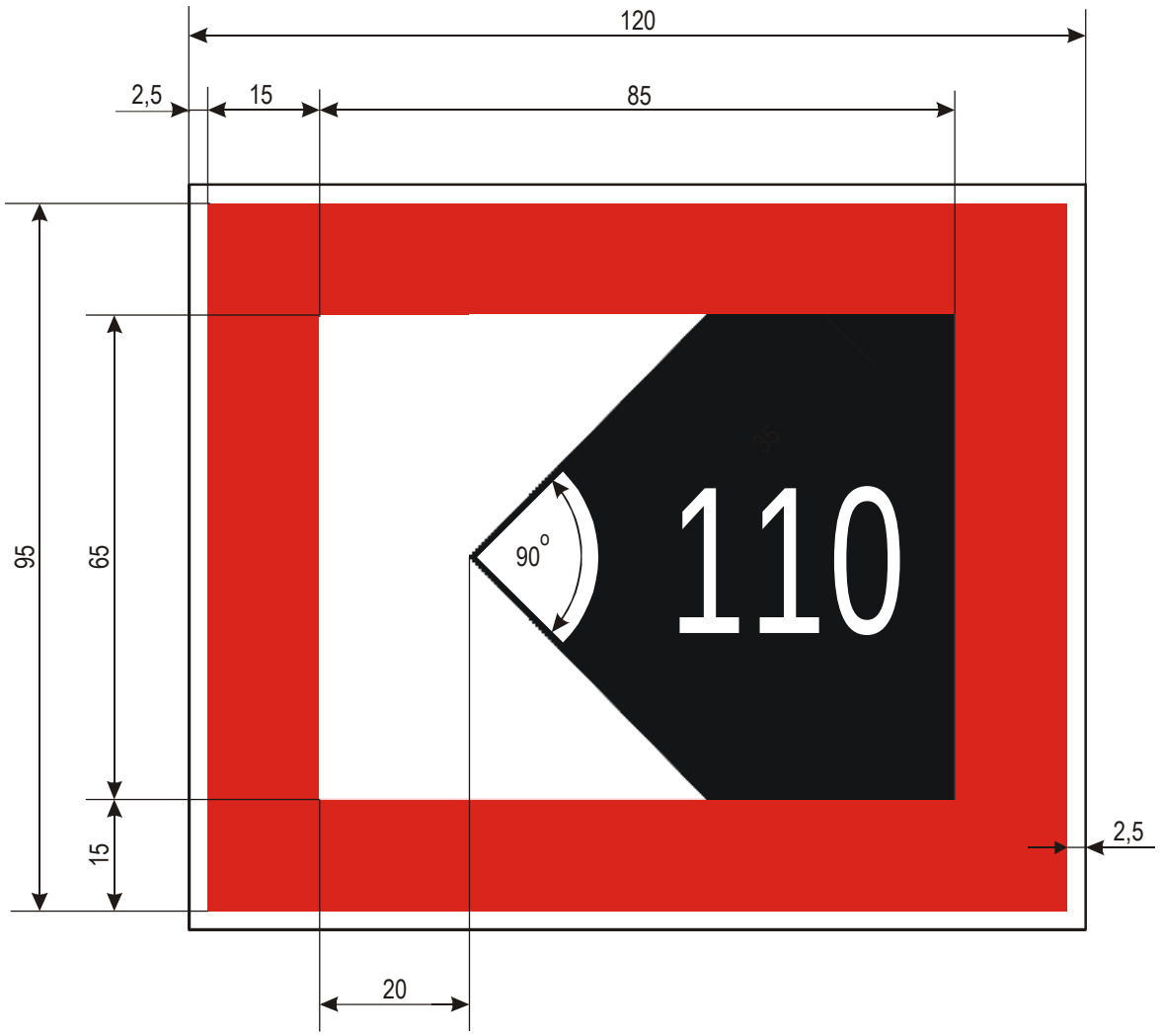

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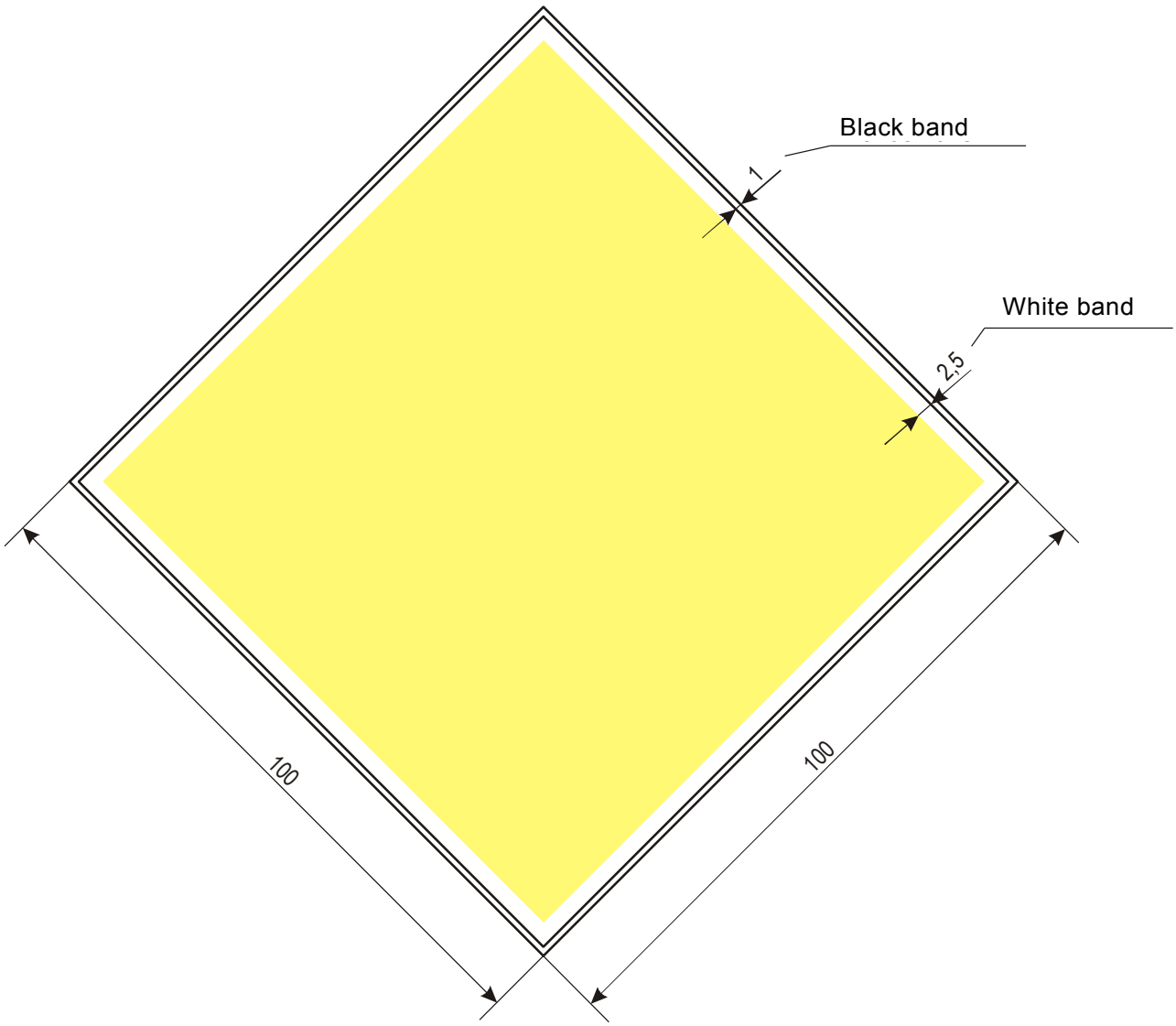

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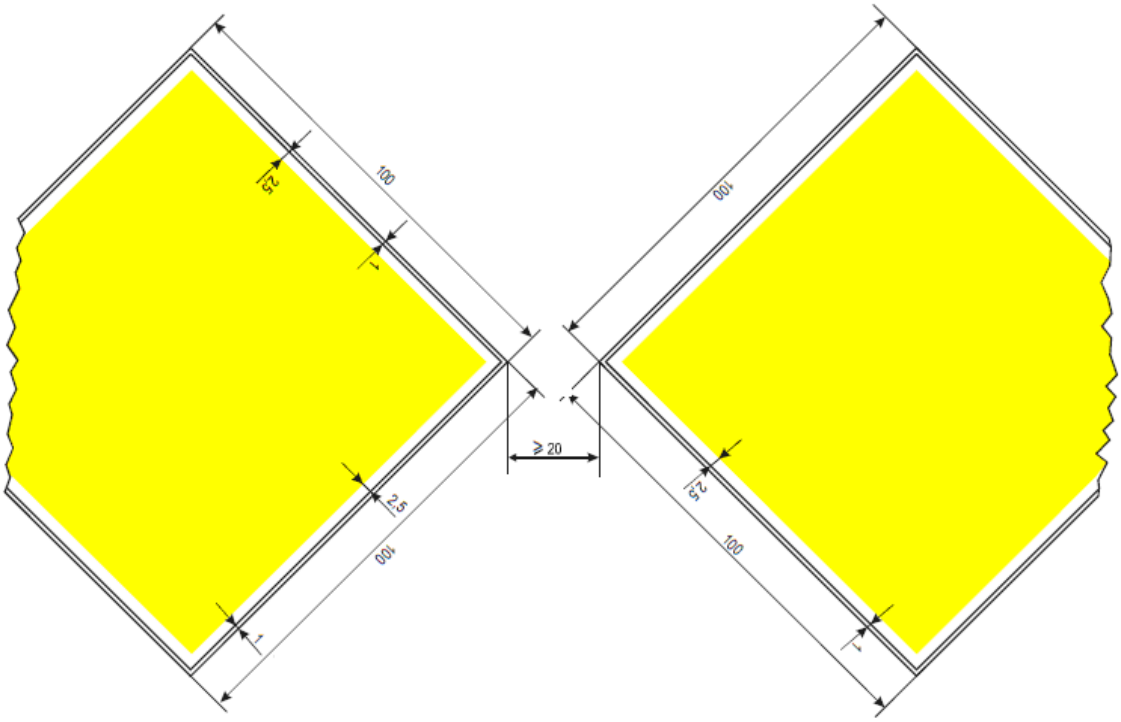

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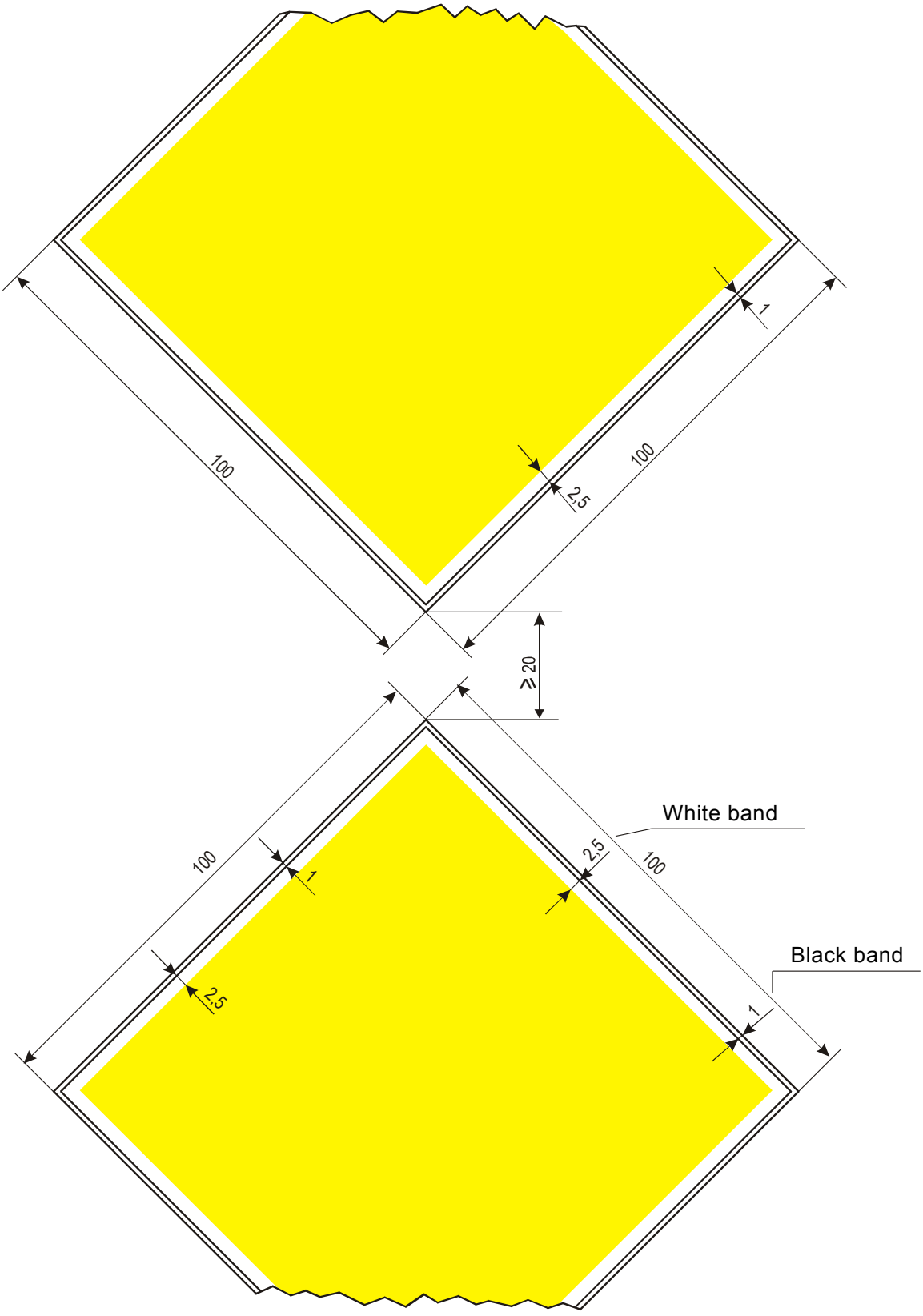

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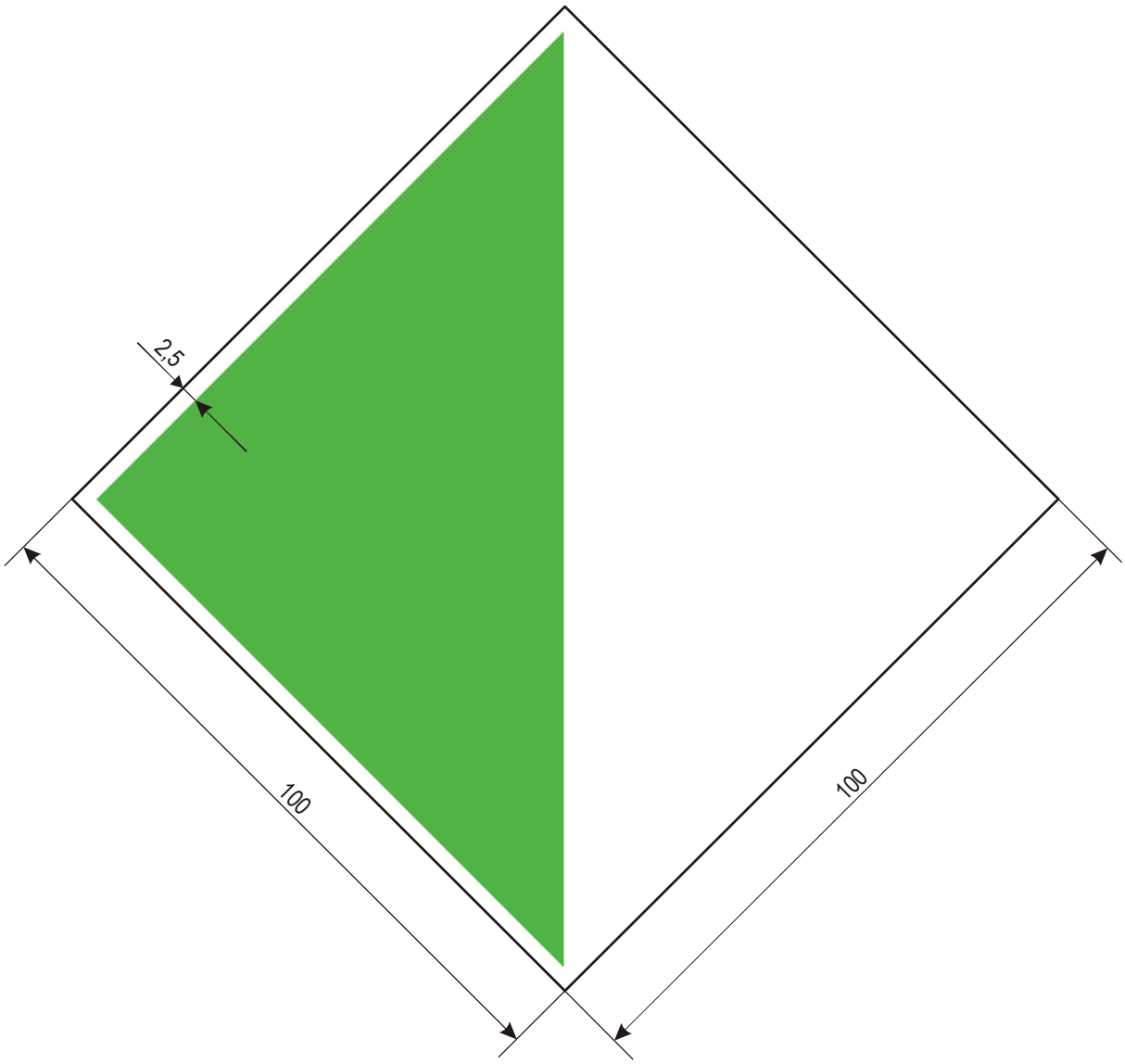

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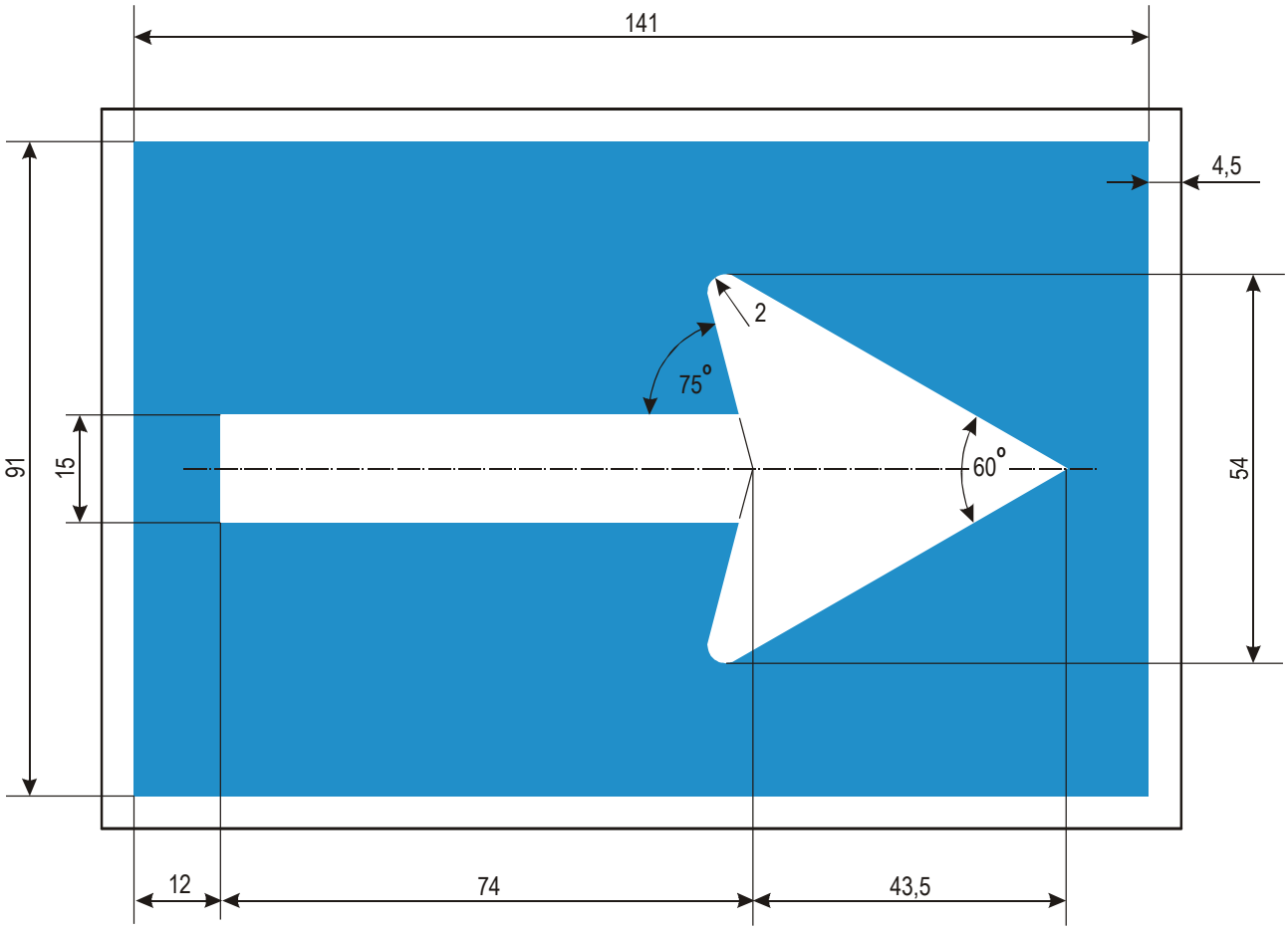

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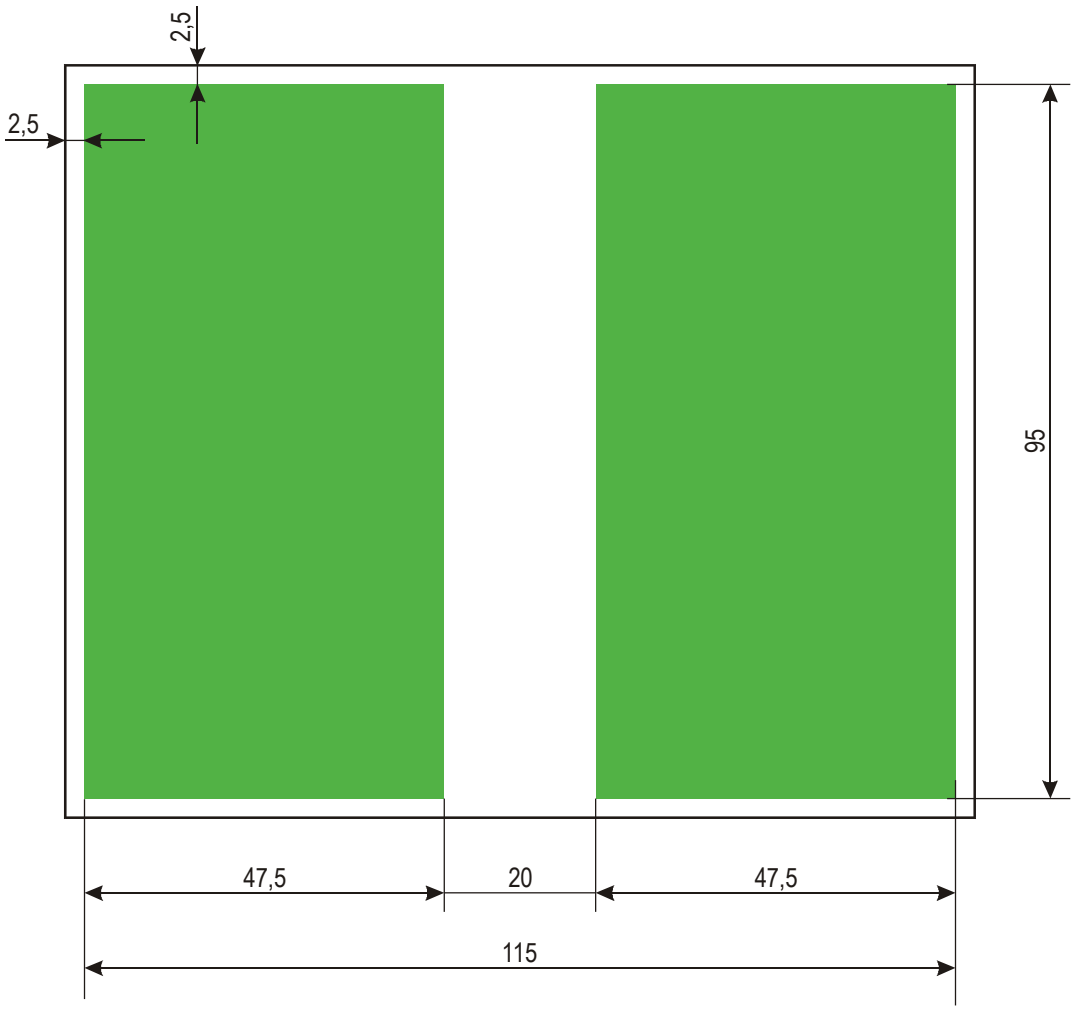

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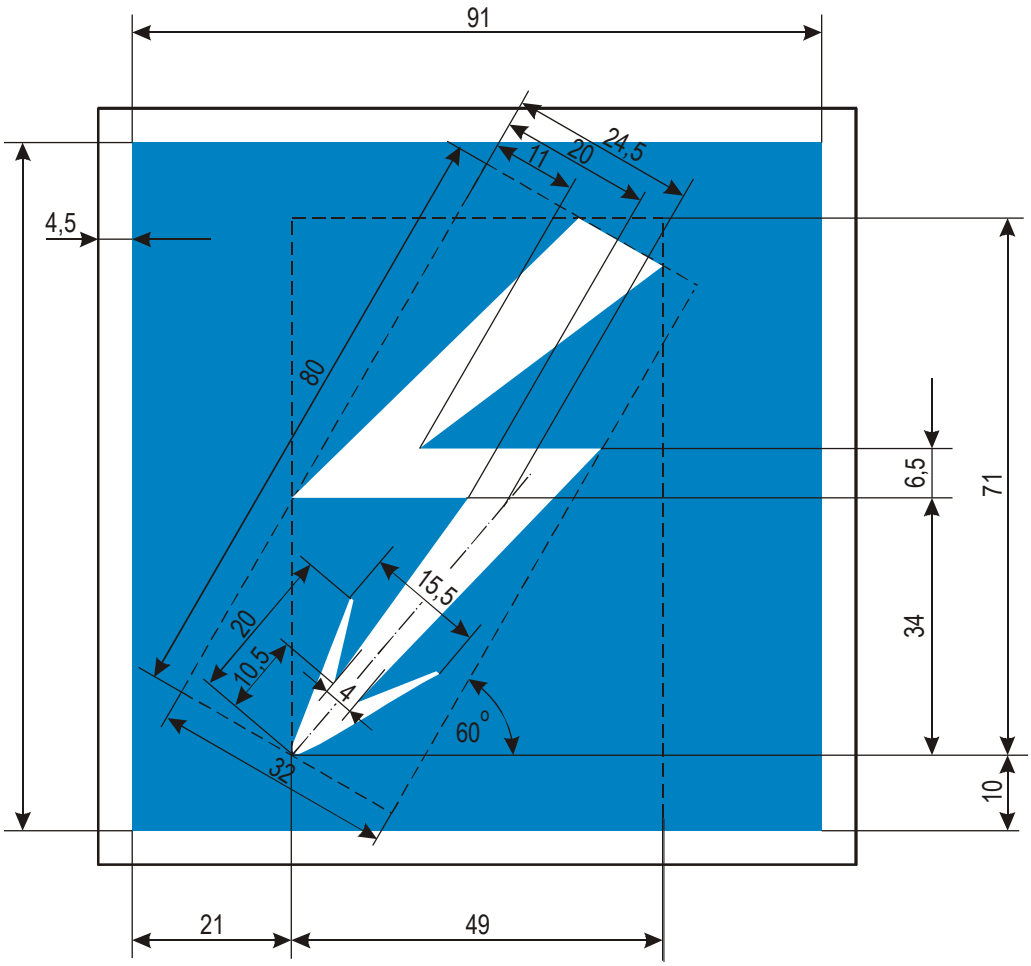

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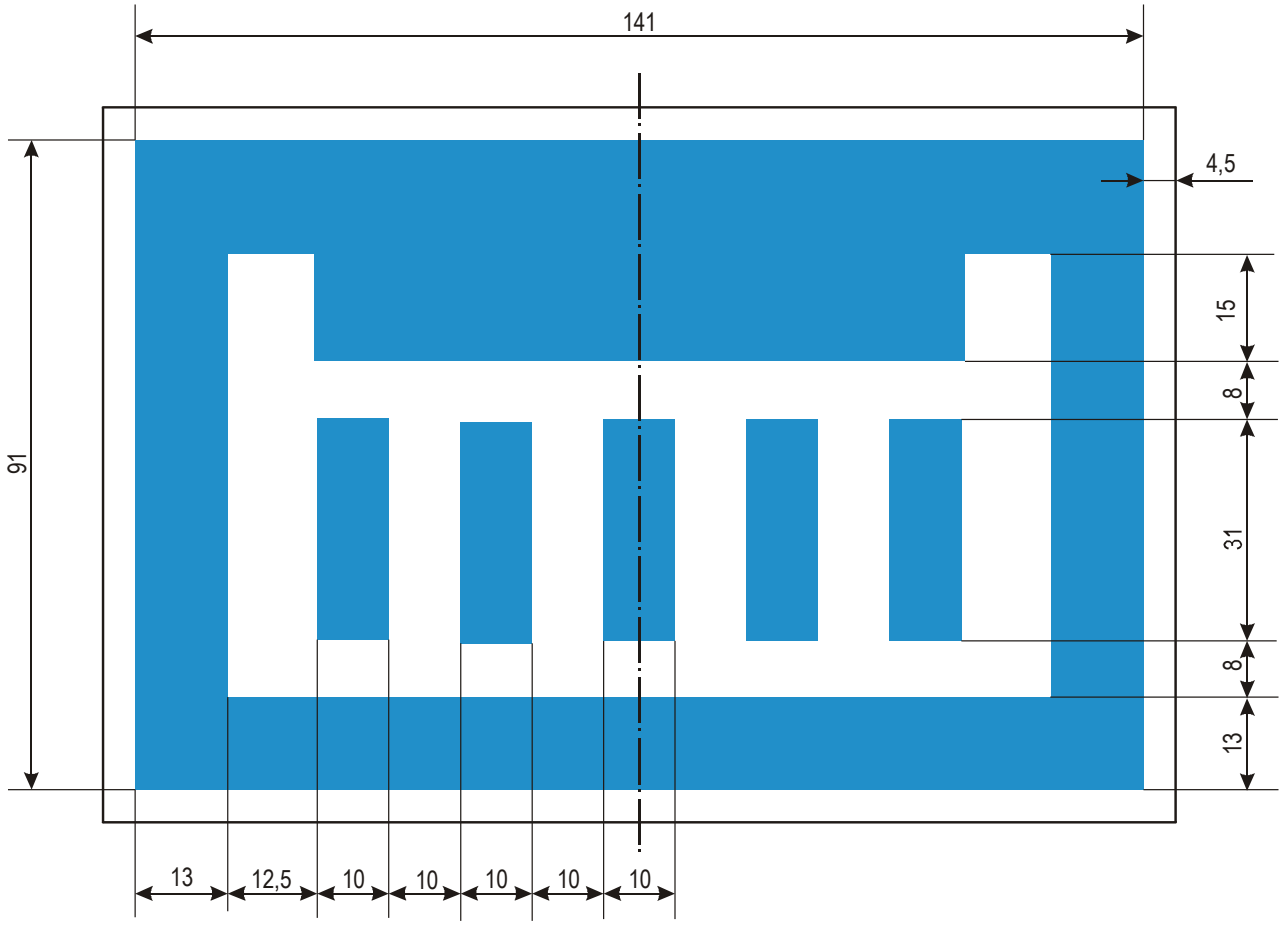

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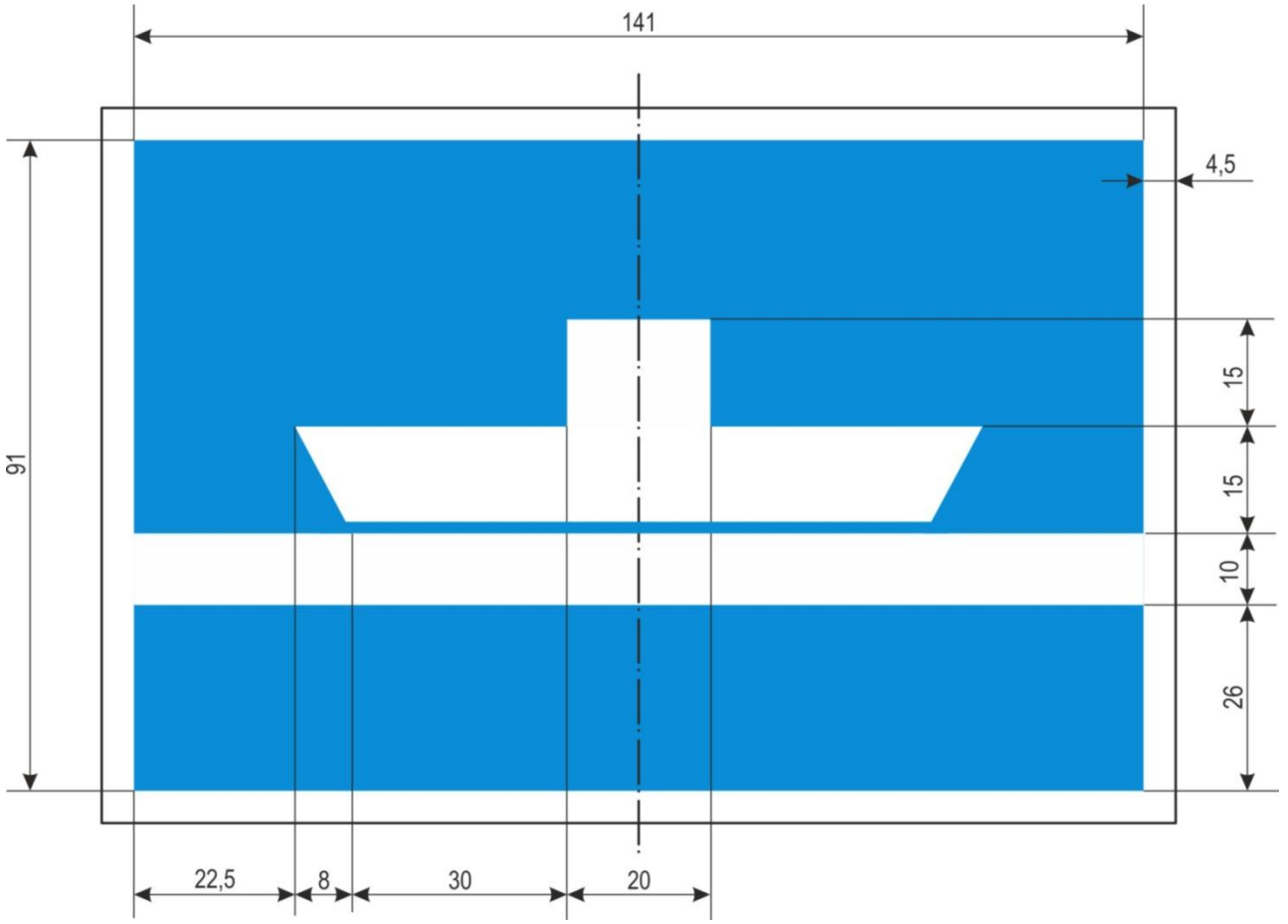

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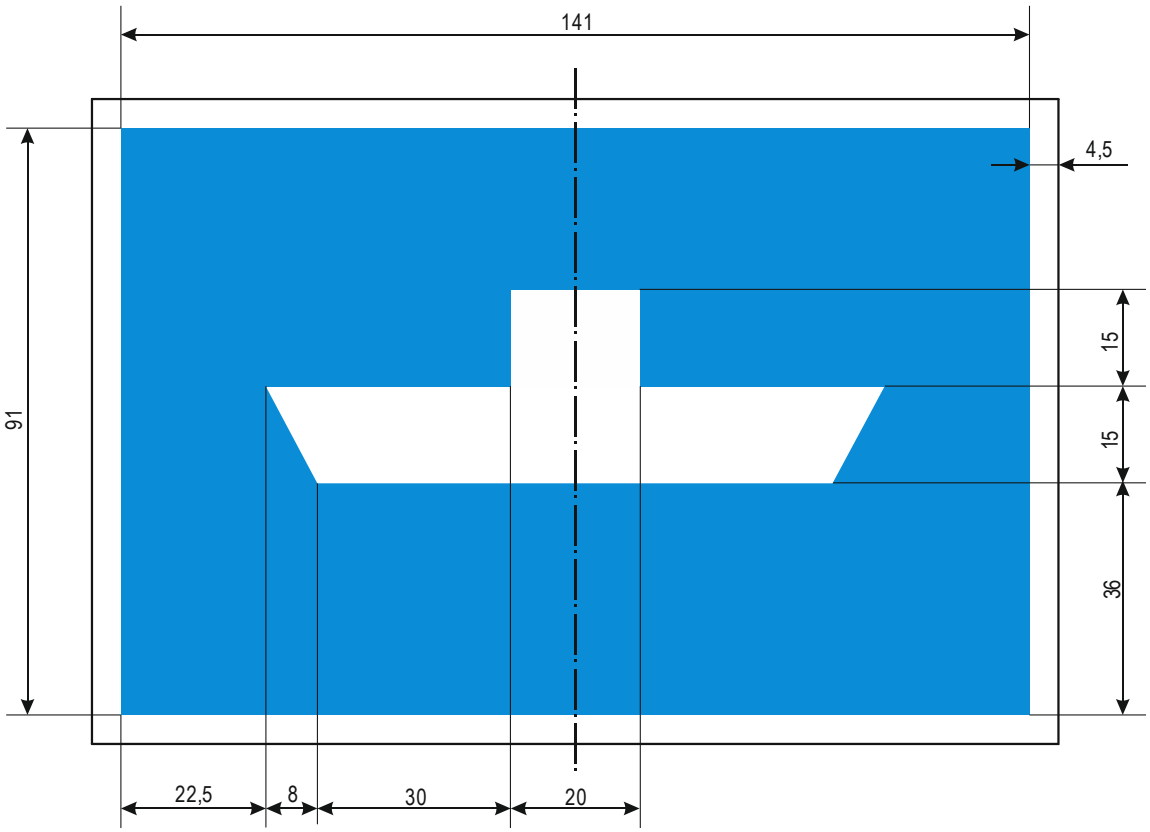

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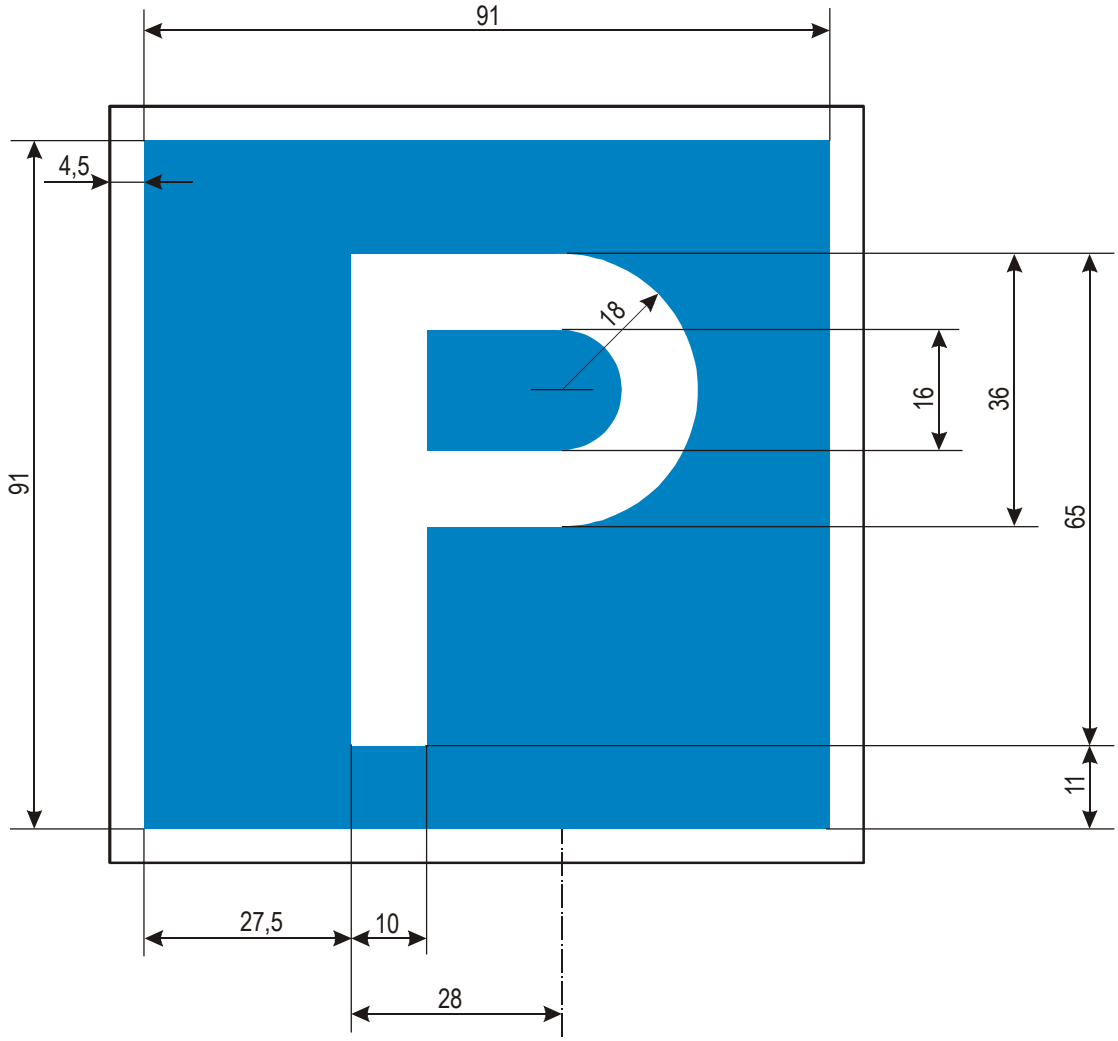

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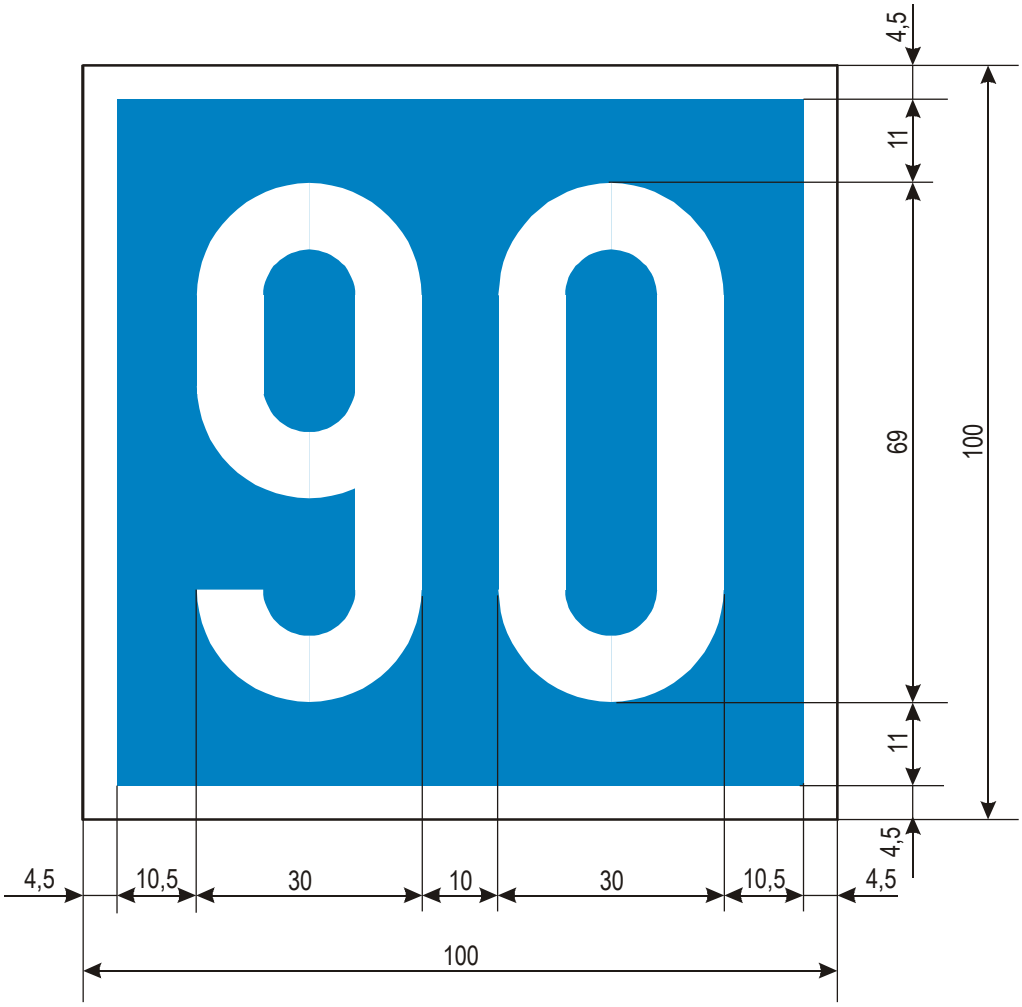

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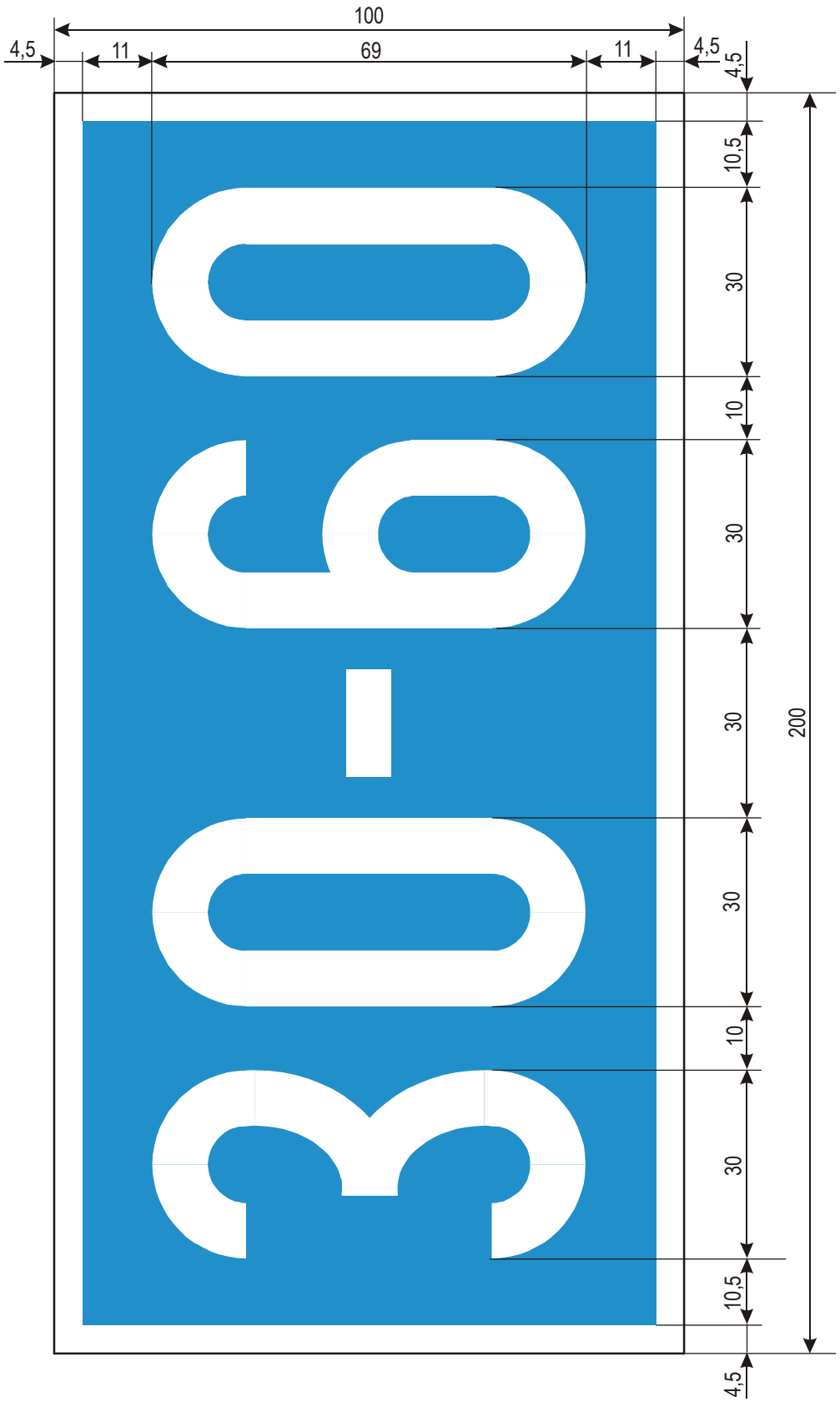

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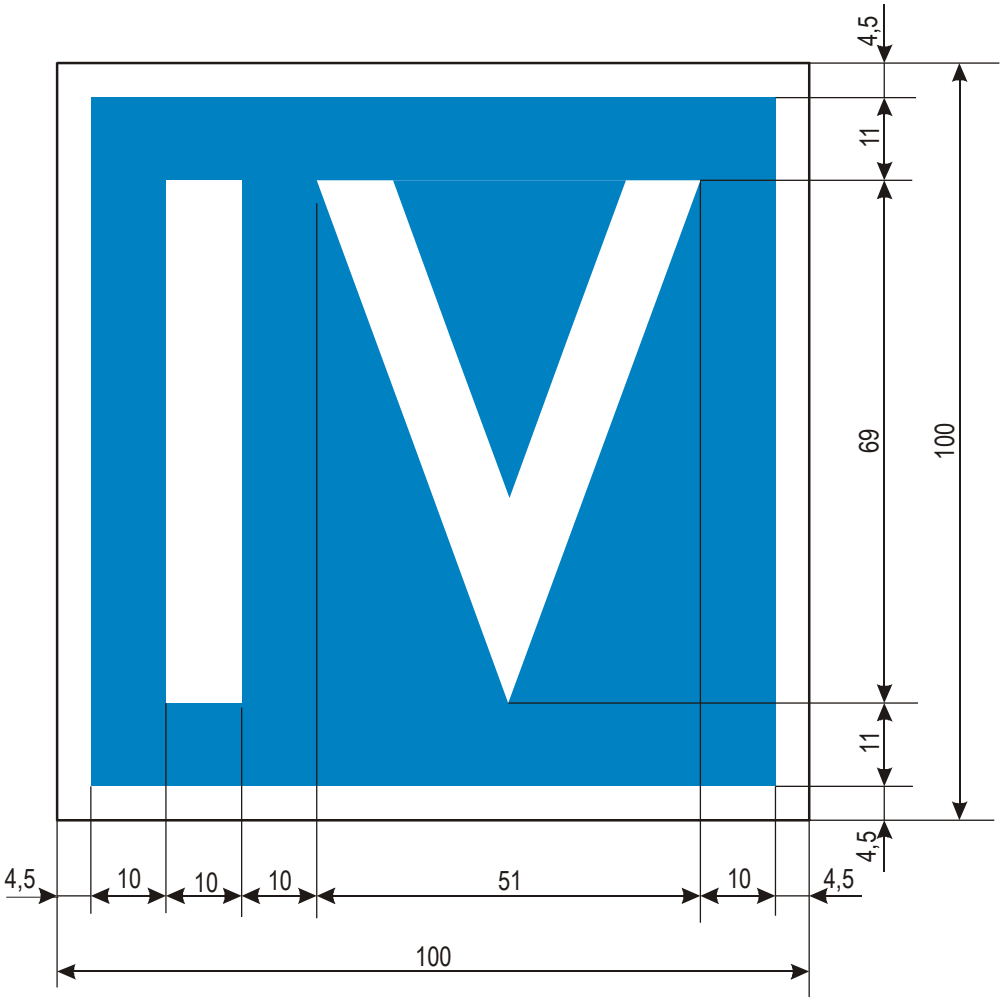

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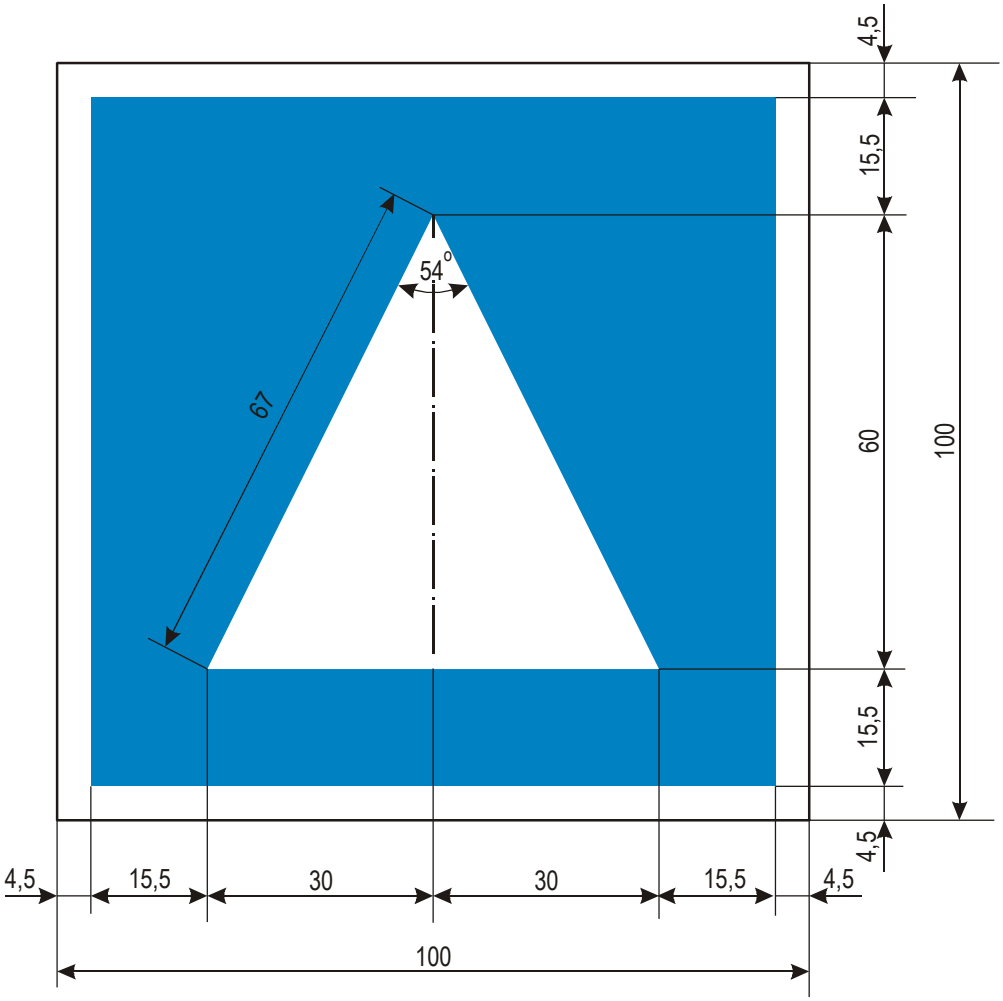

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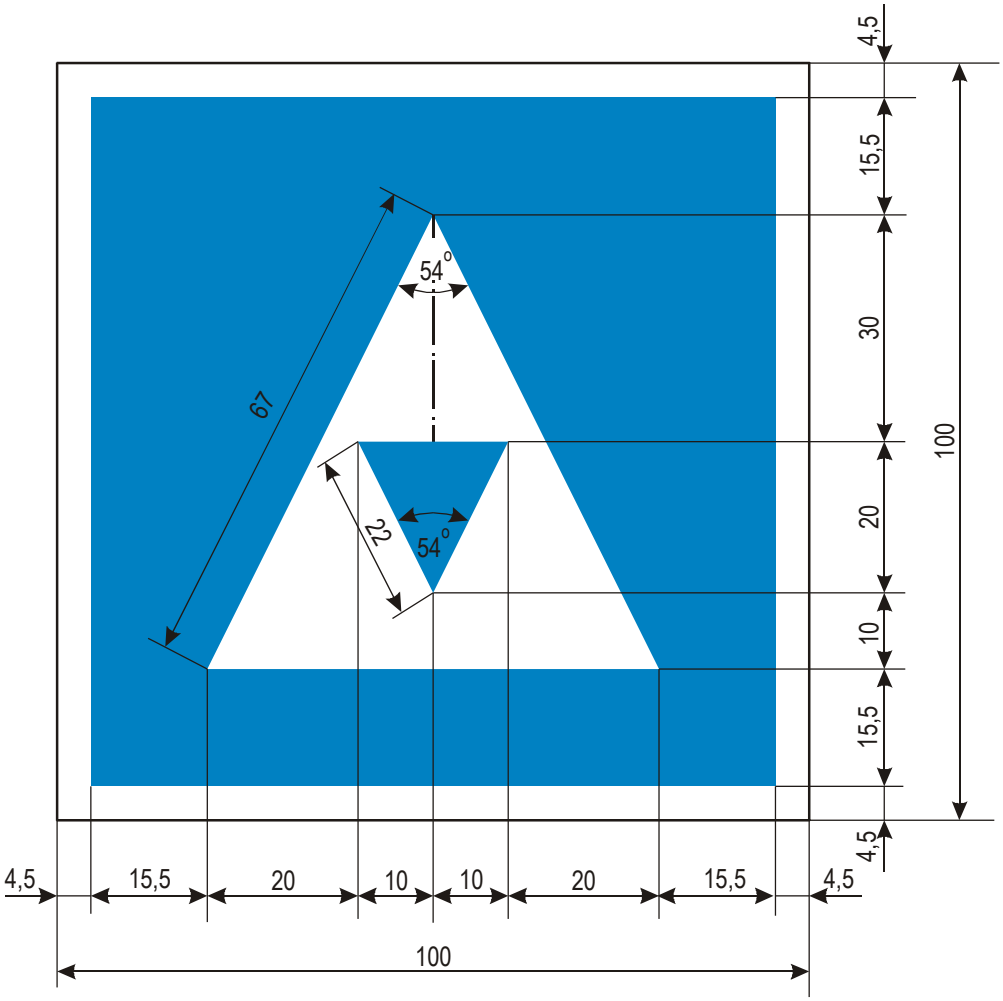

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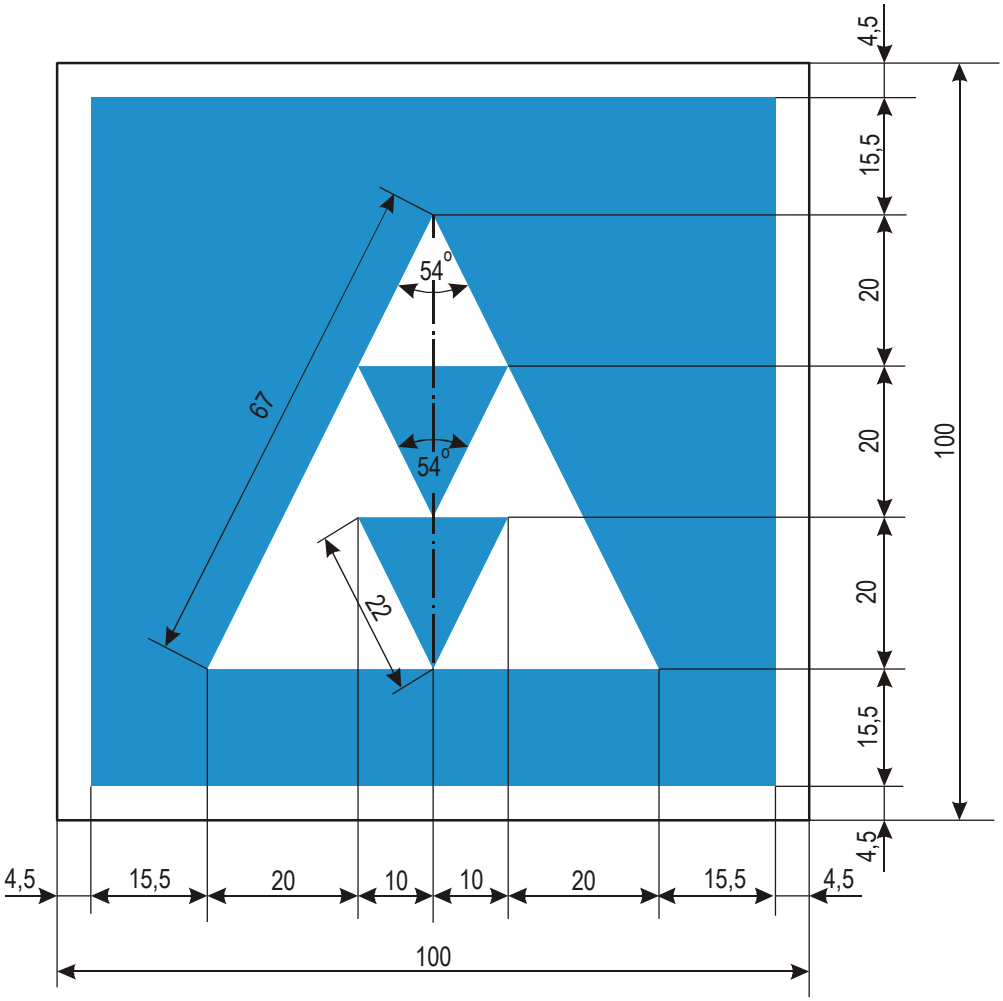

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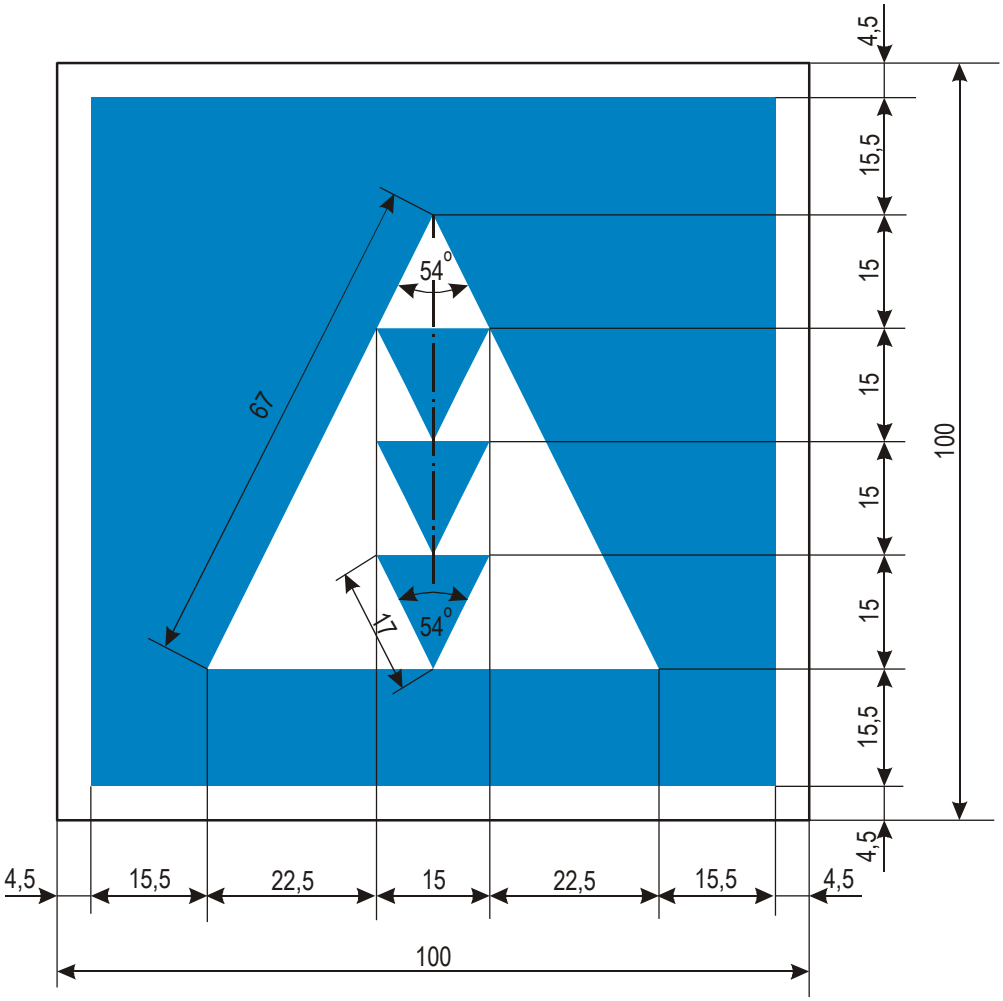
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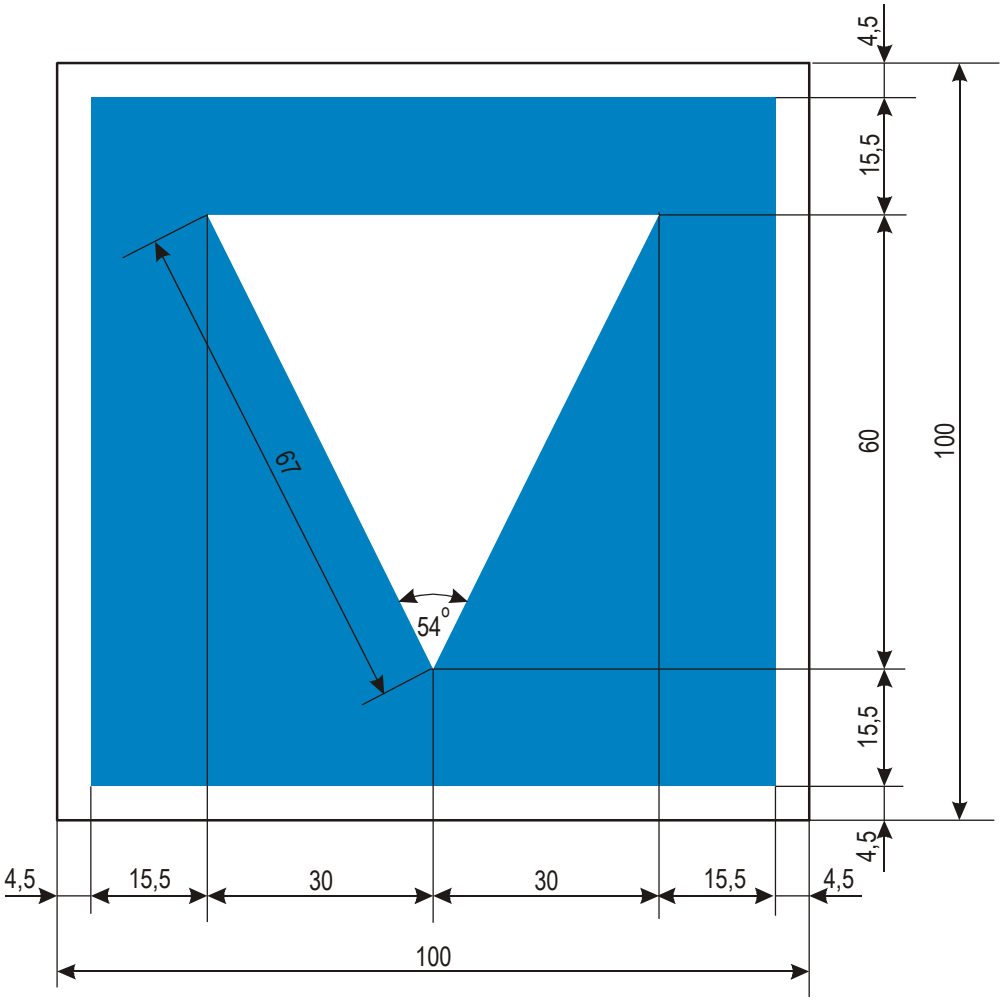
E. 5.8



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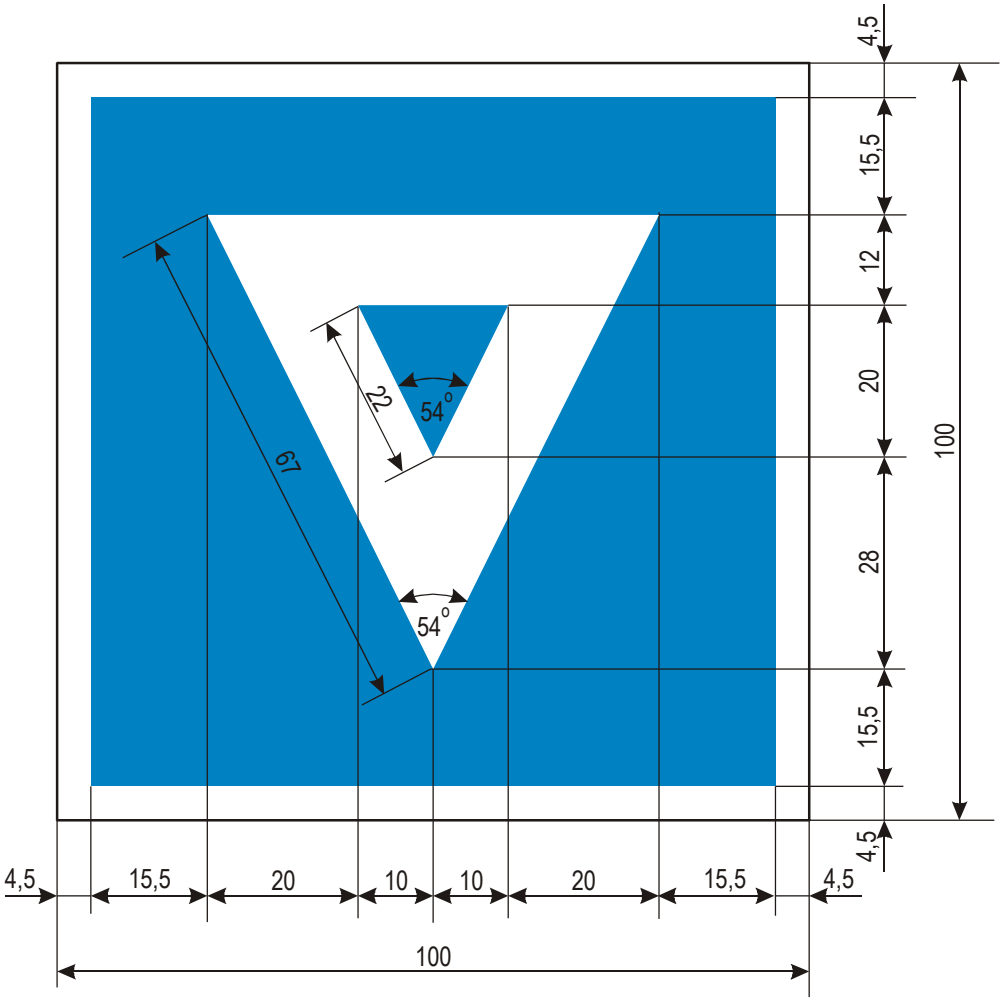

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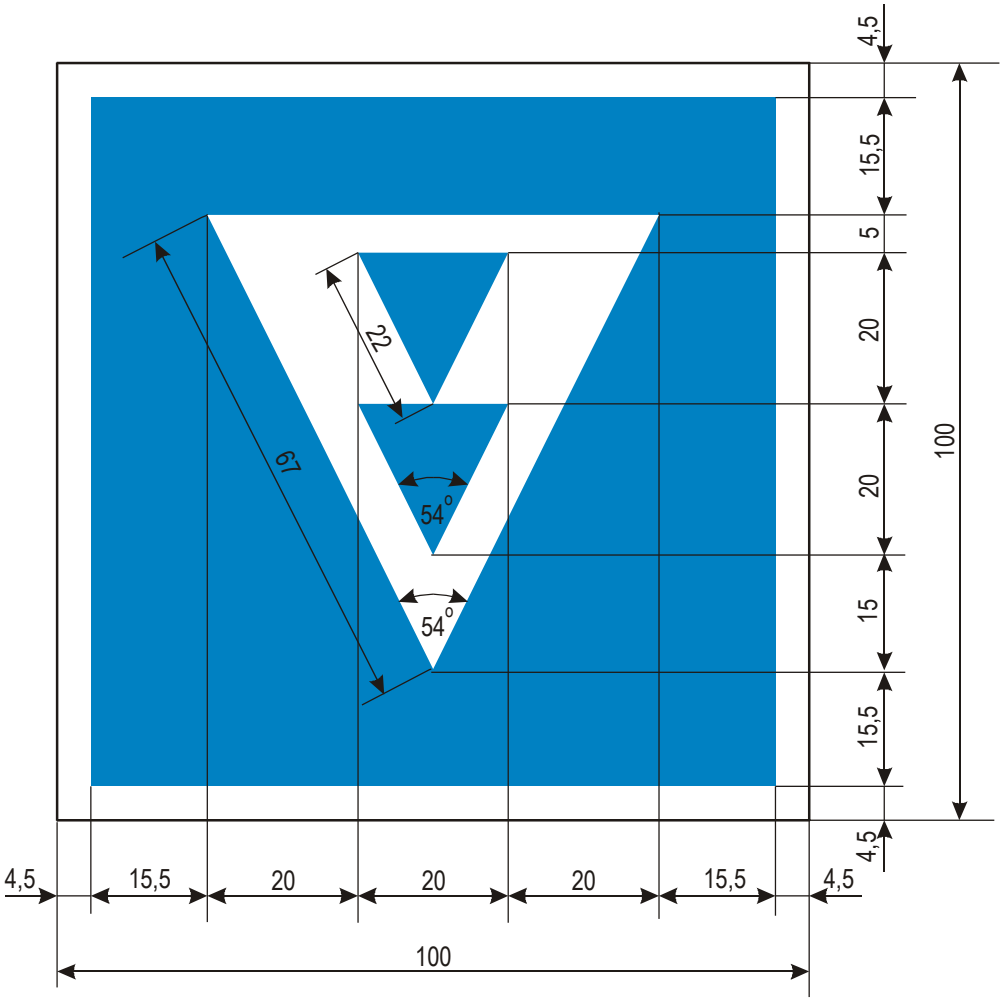

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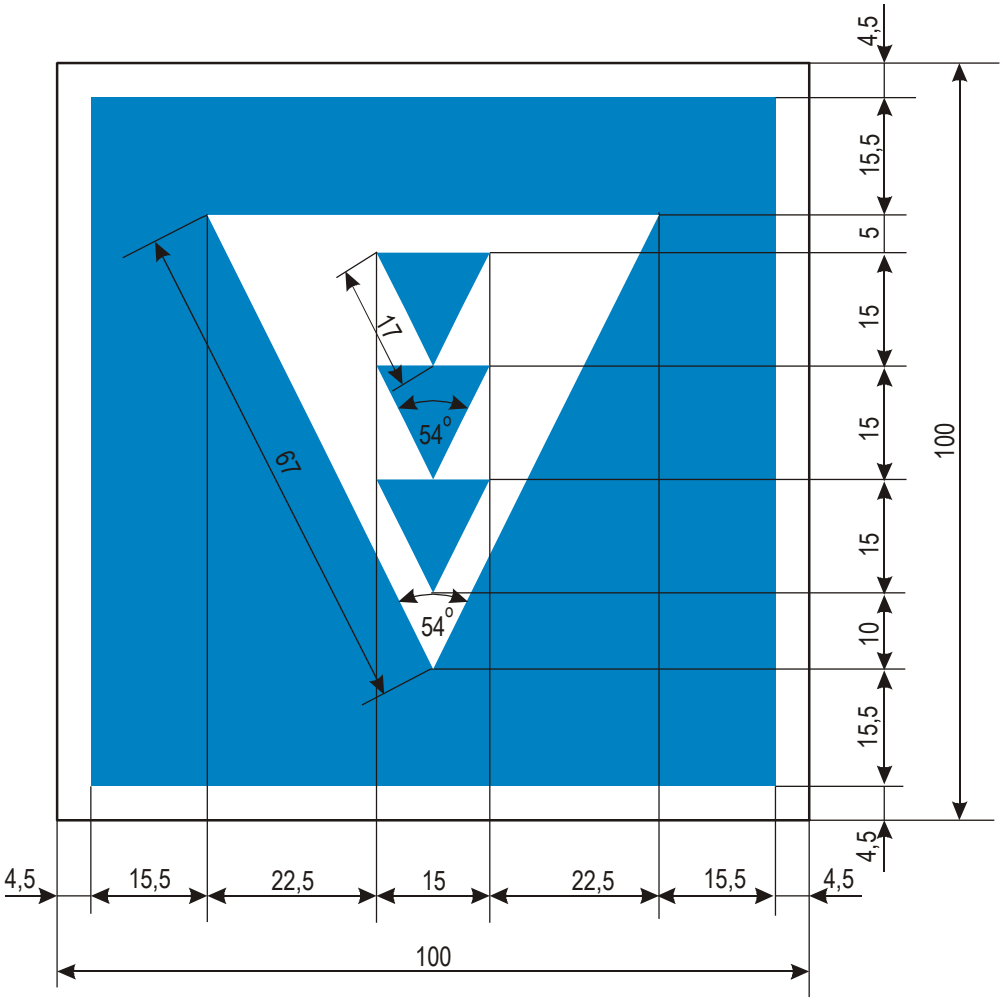
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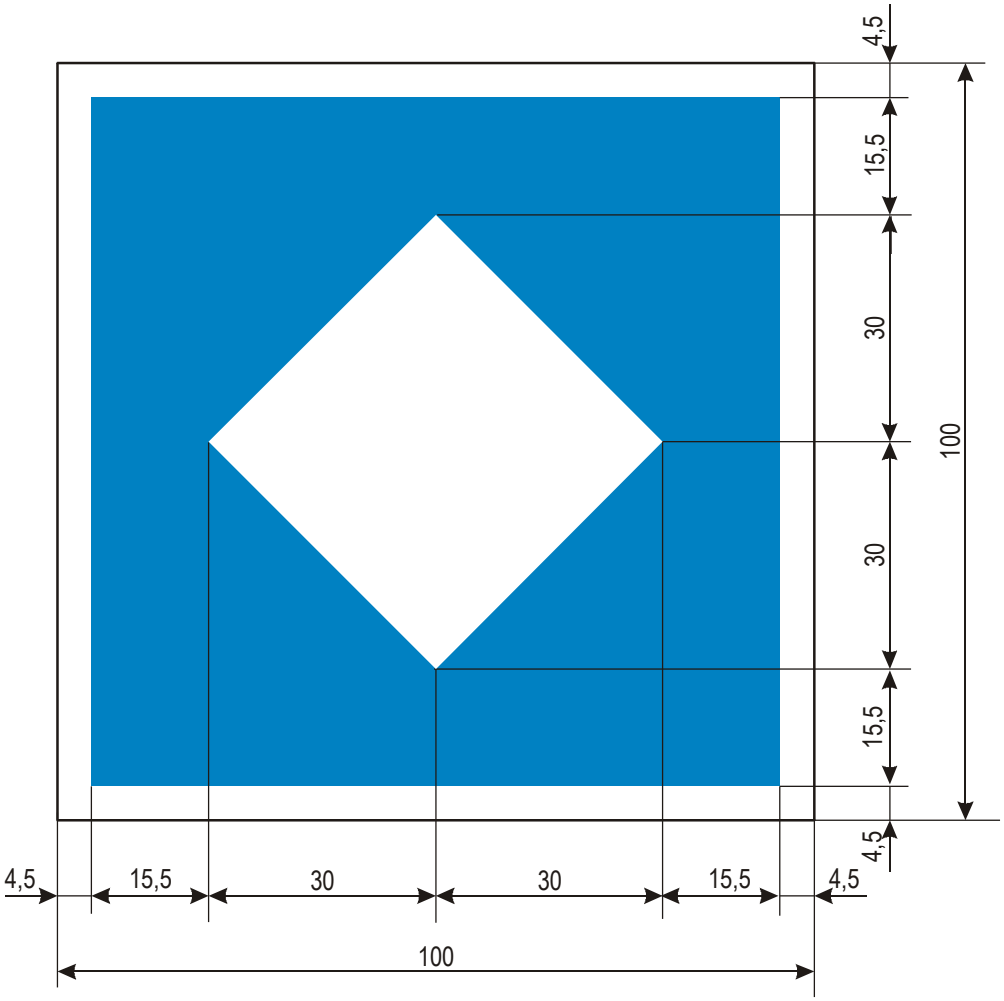
E. 5.12



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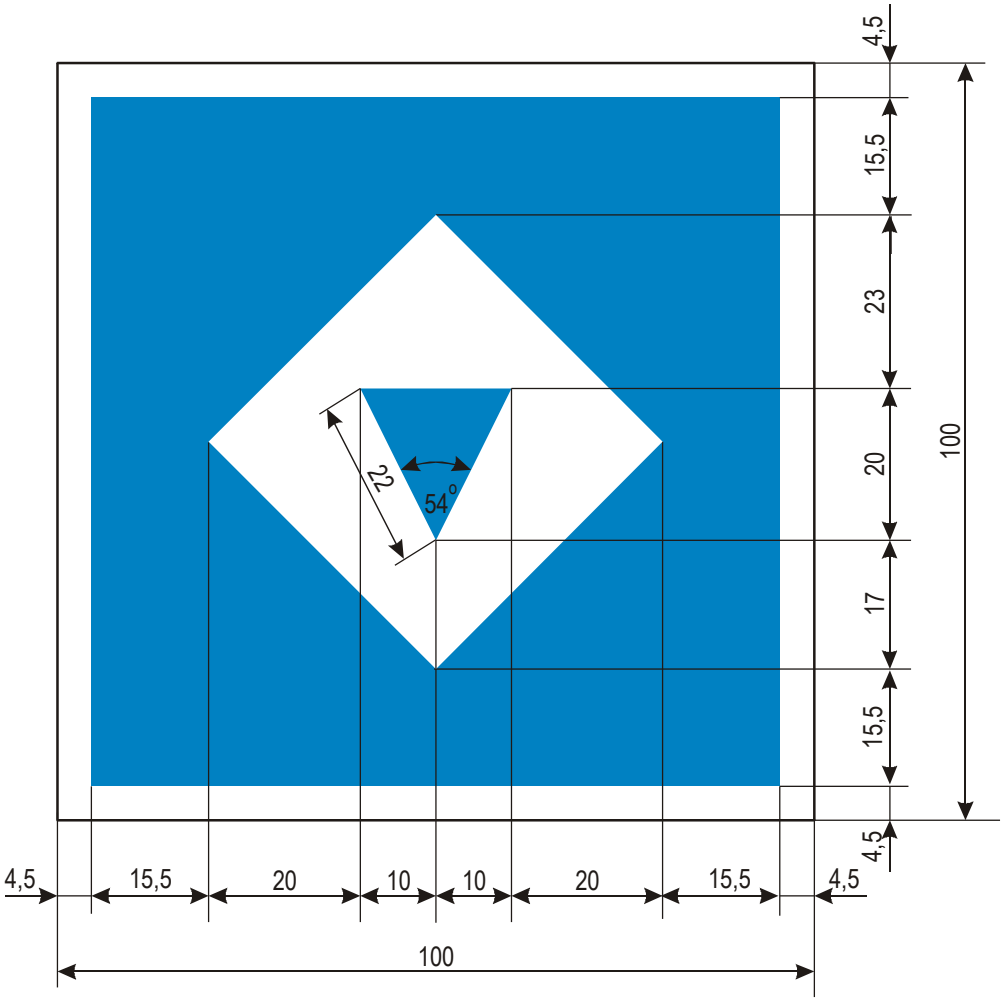

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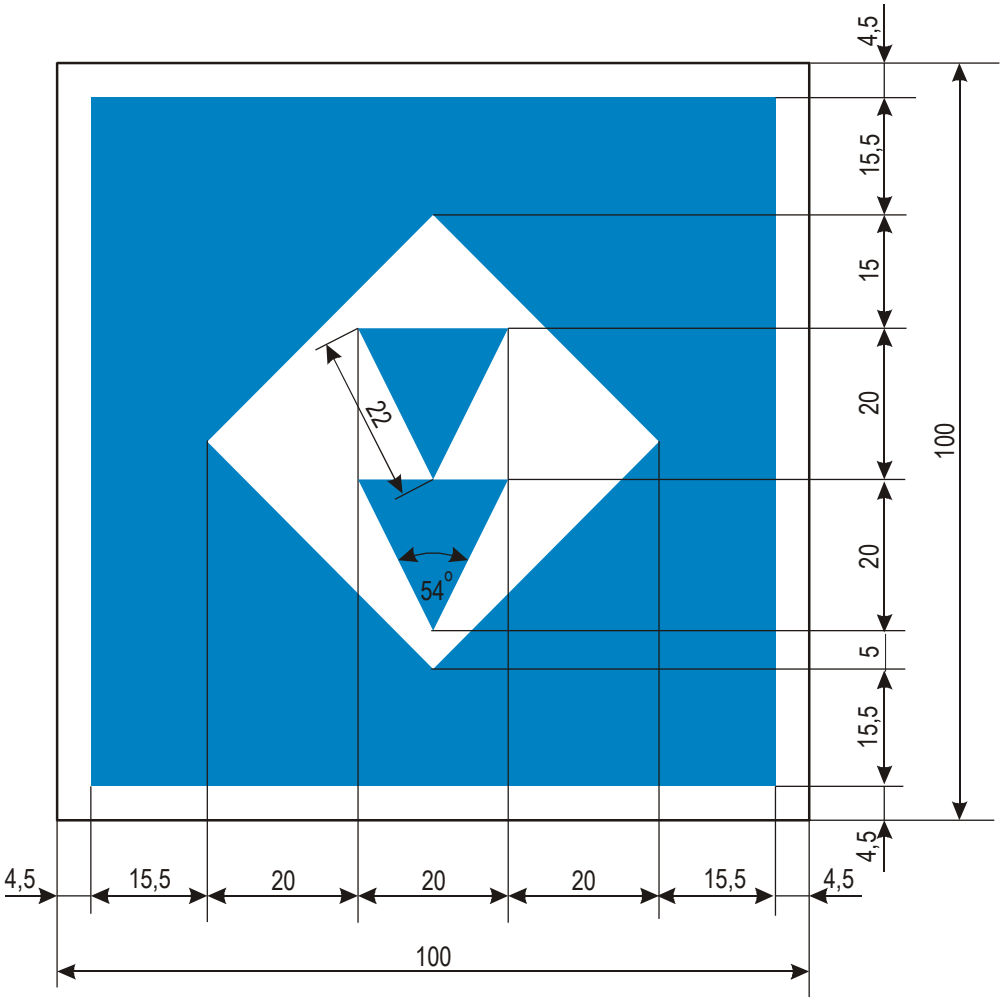

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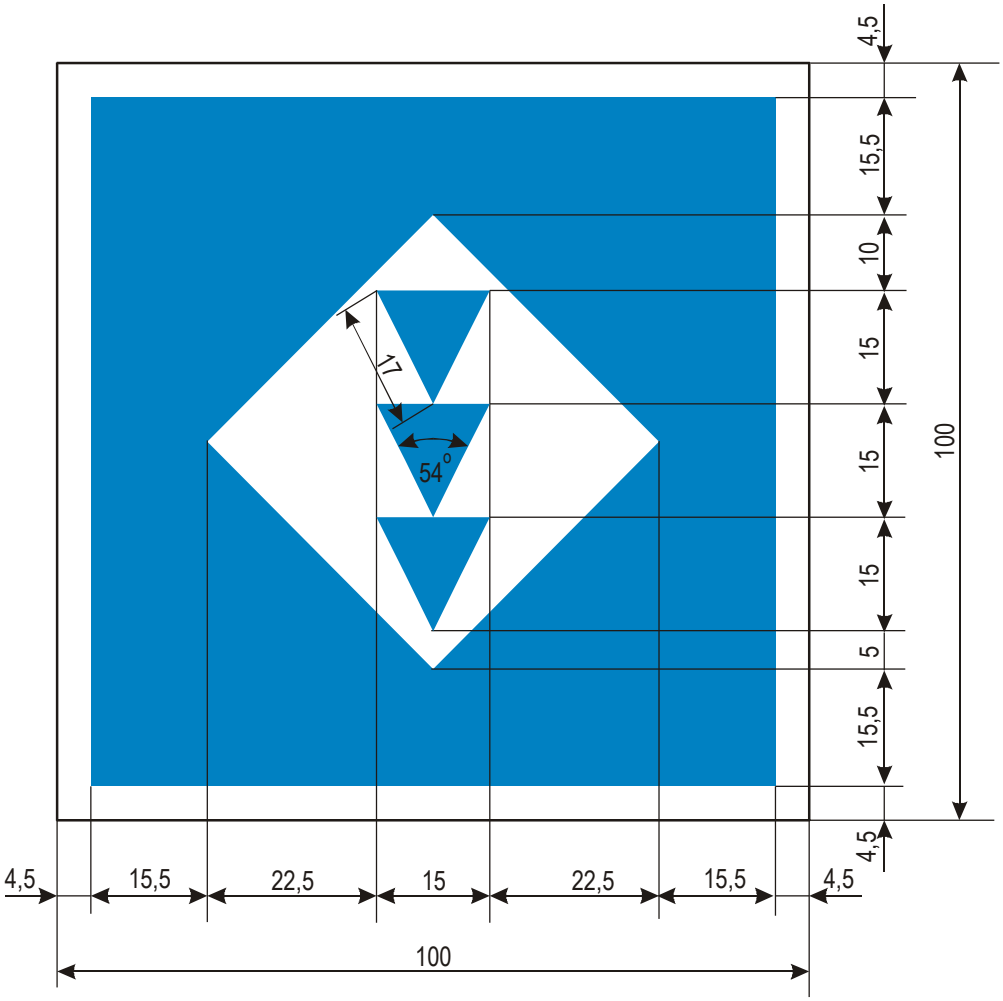

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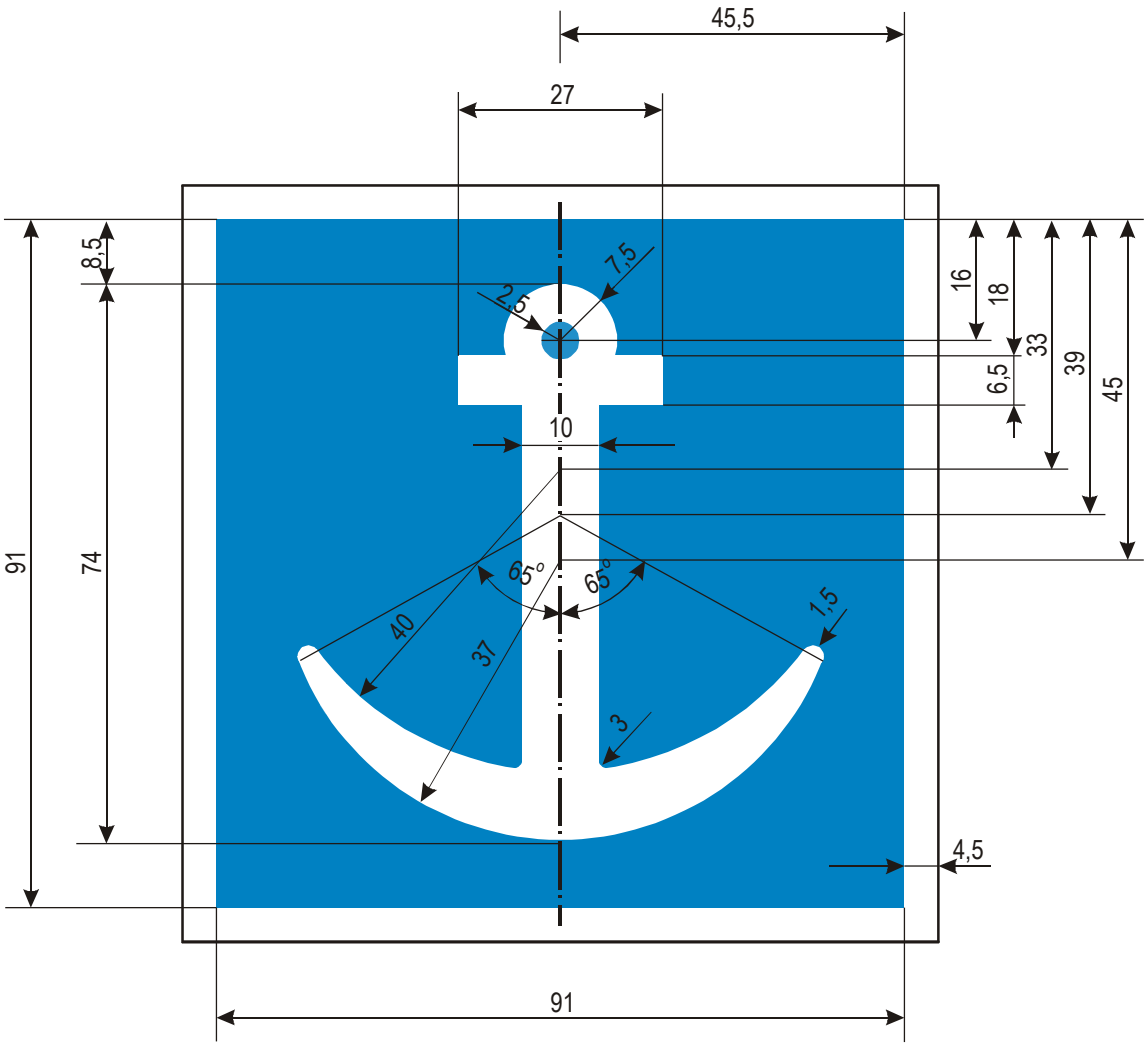

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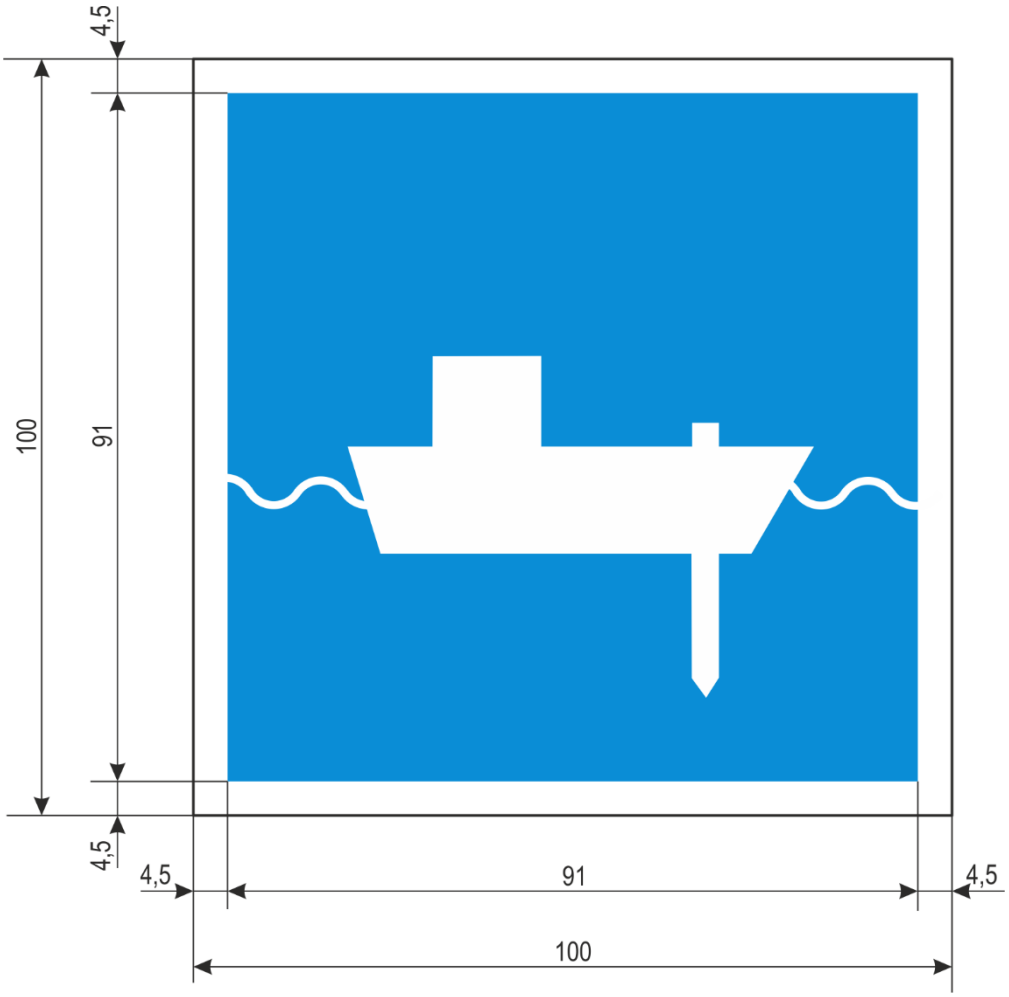

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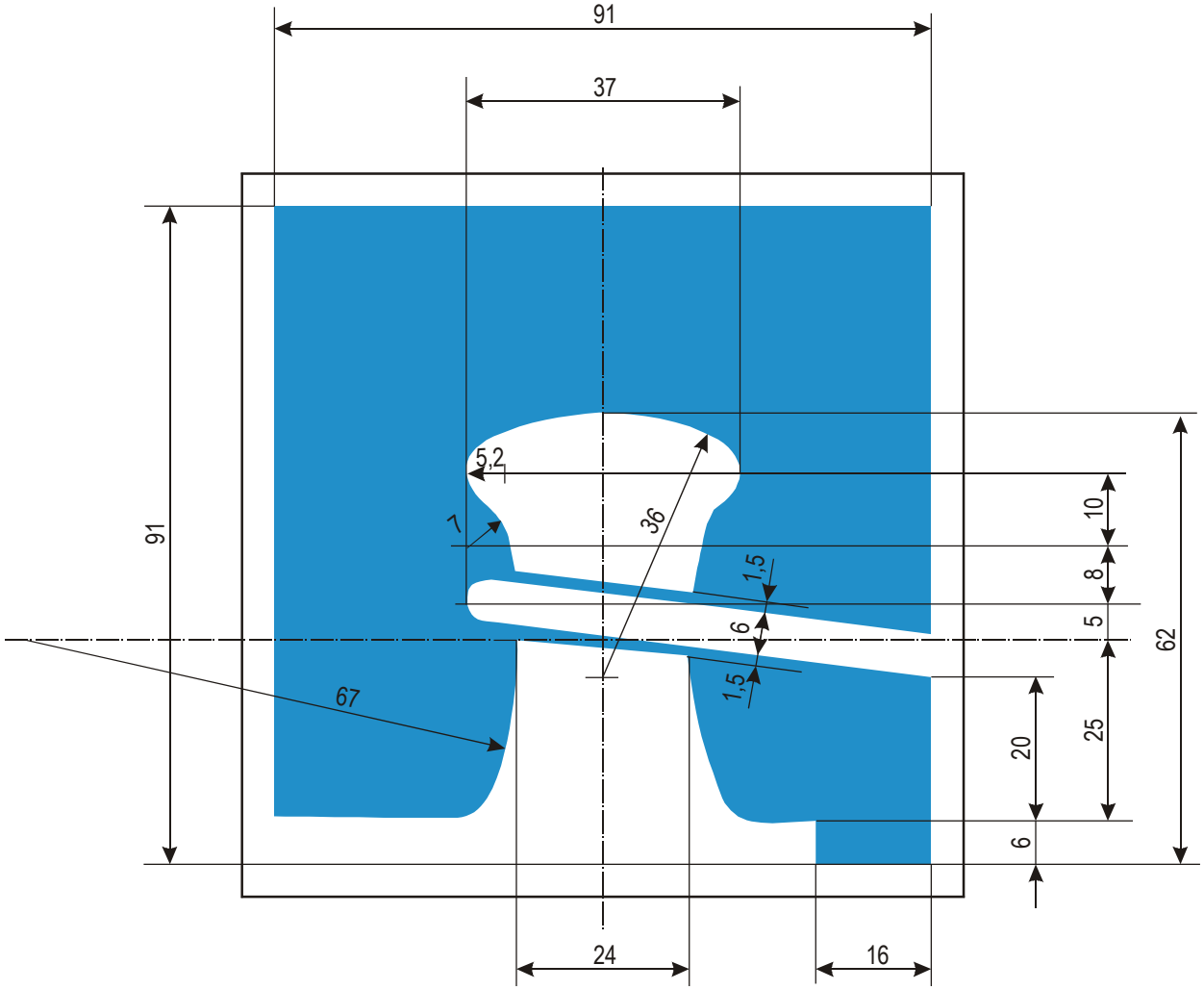

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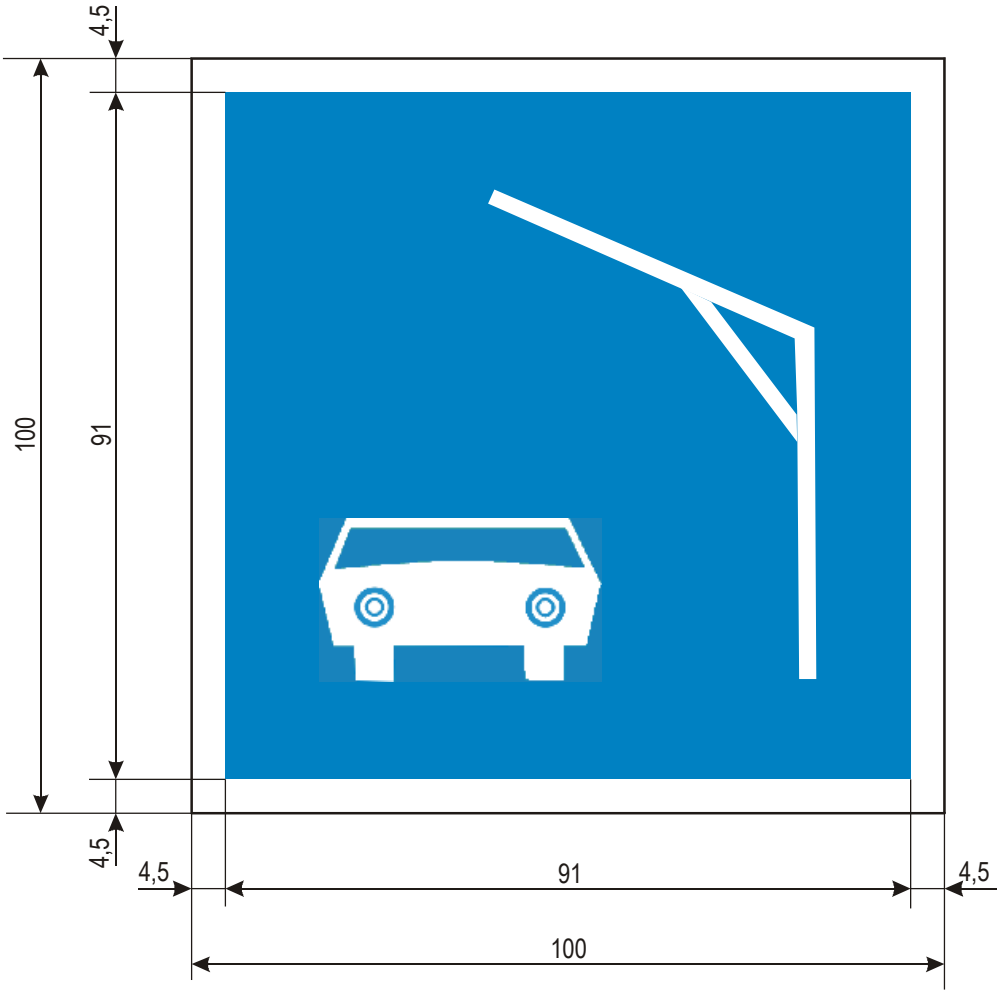

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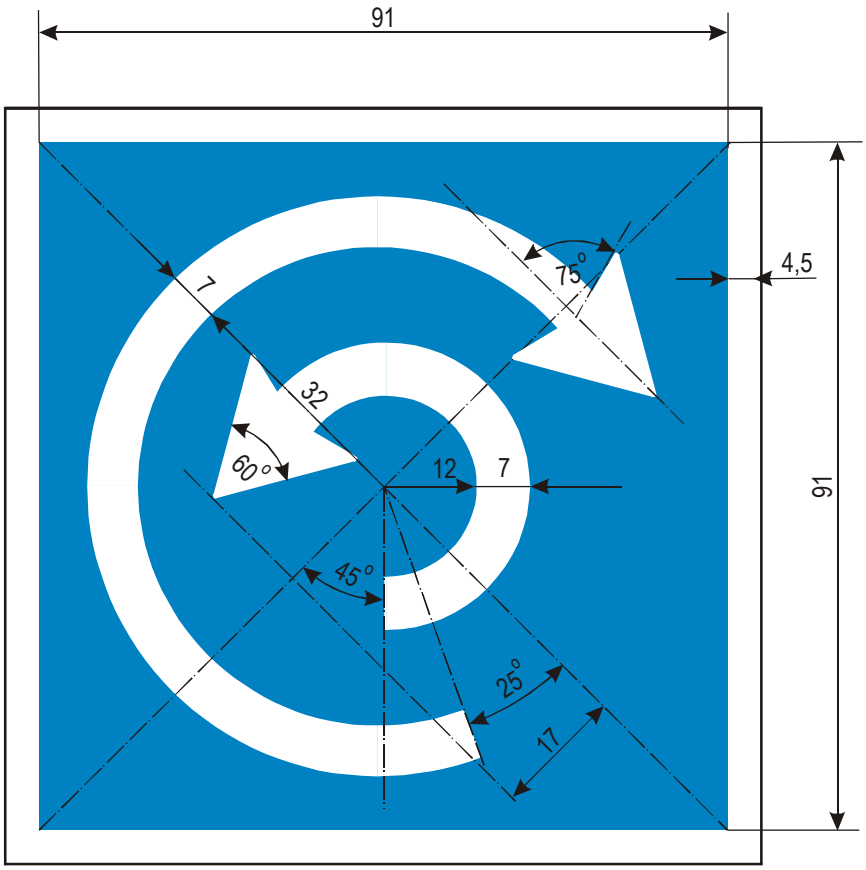

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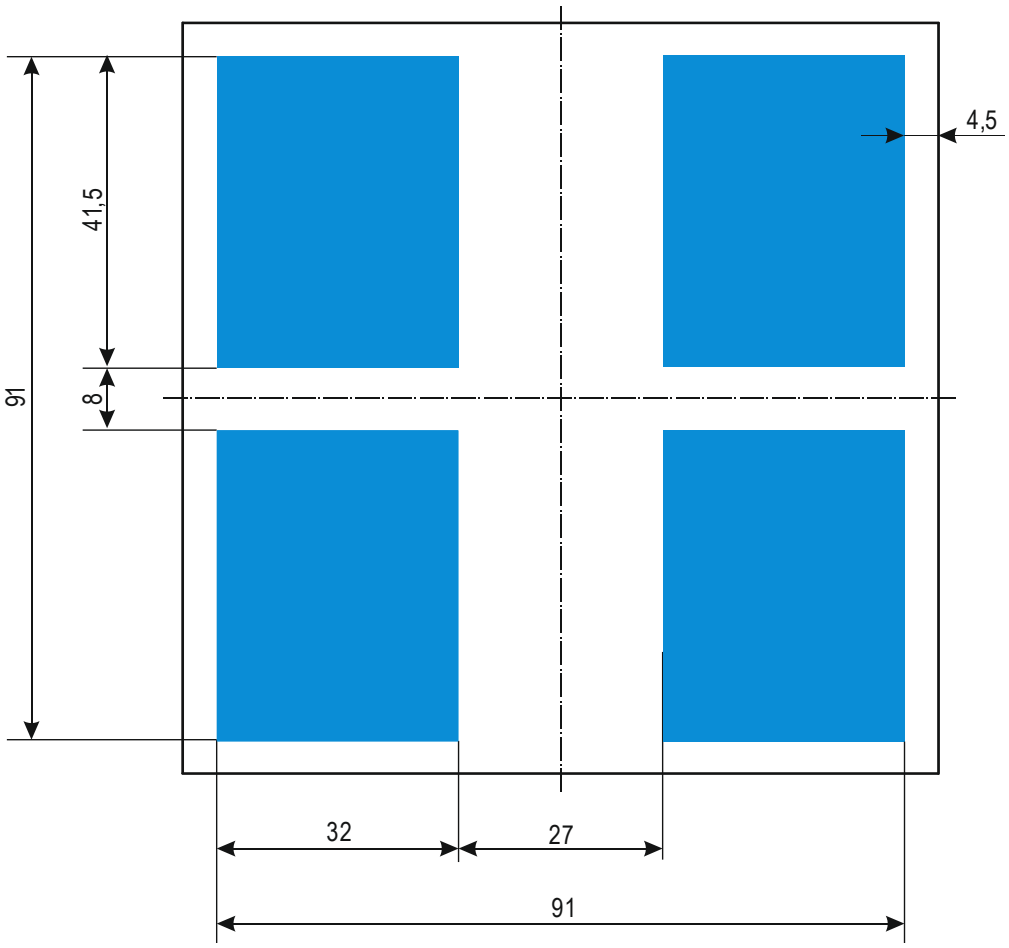

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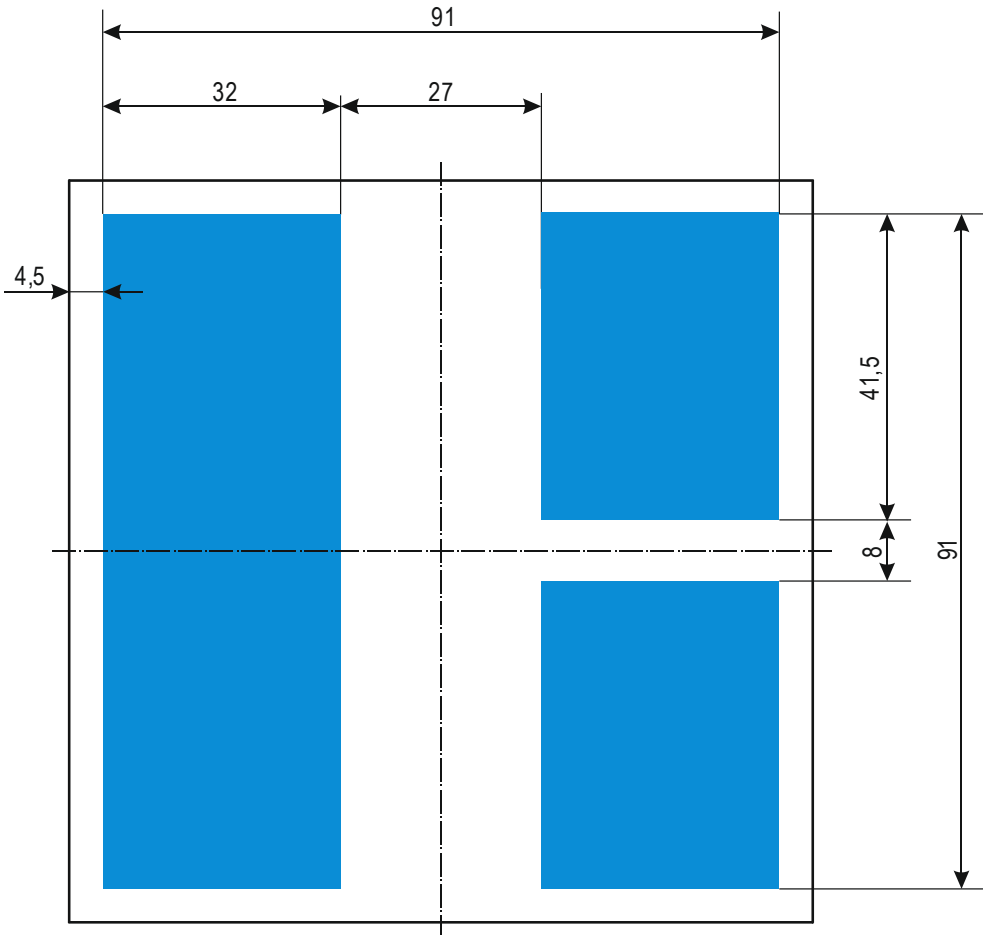

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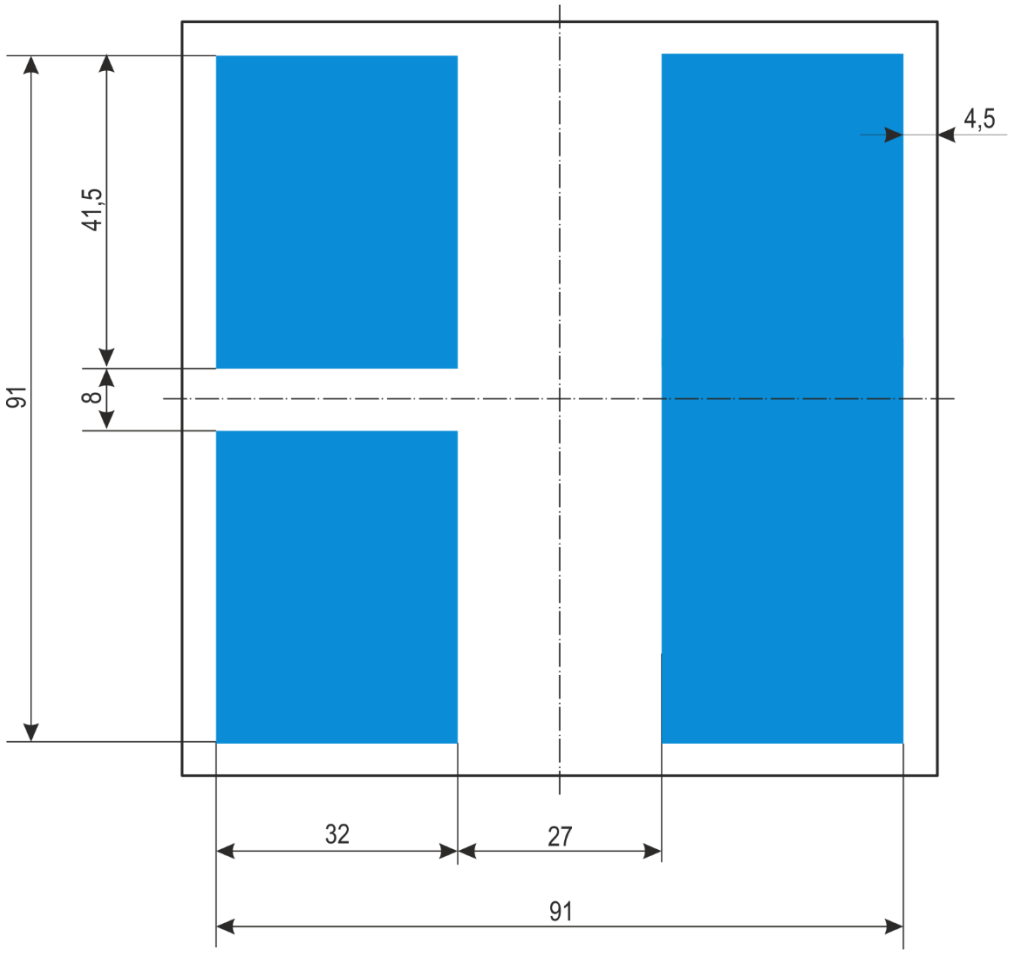

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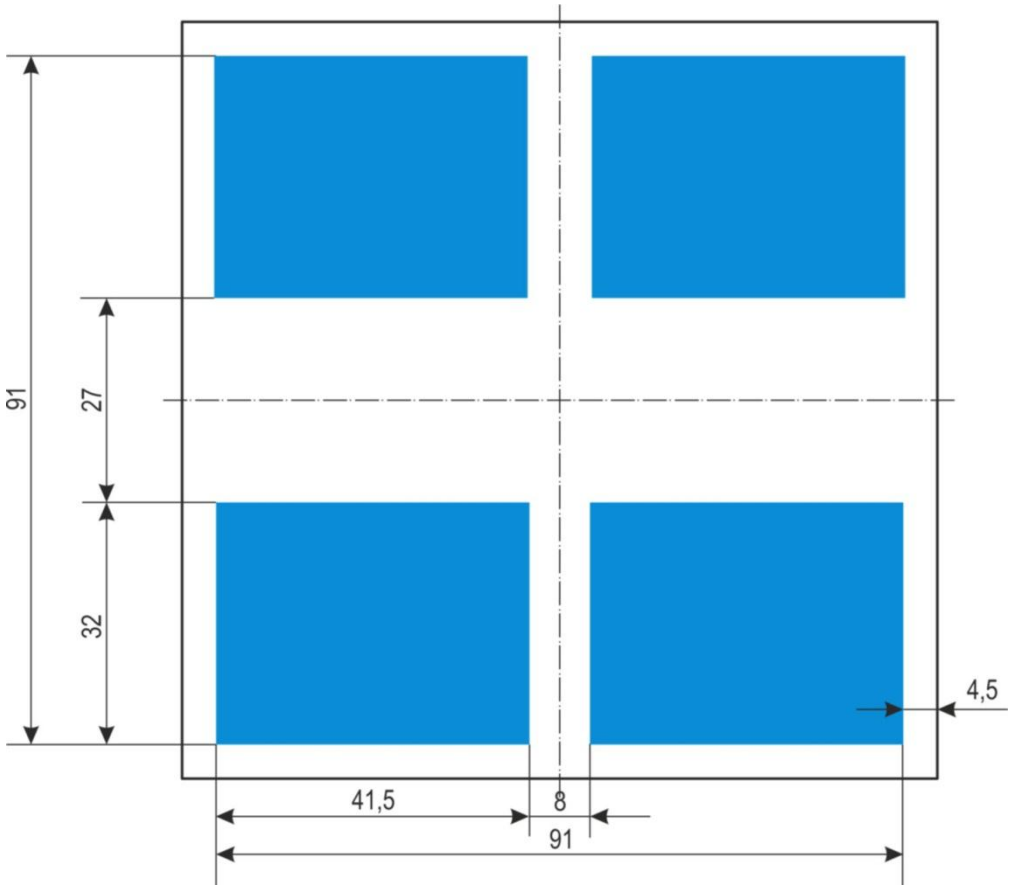

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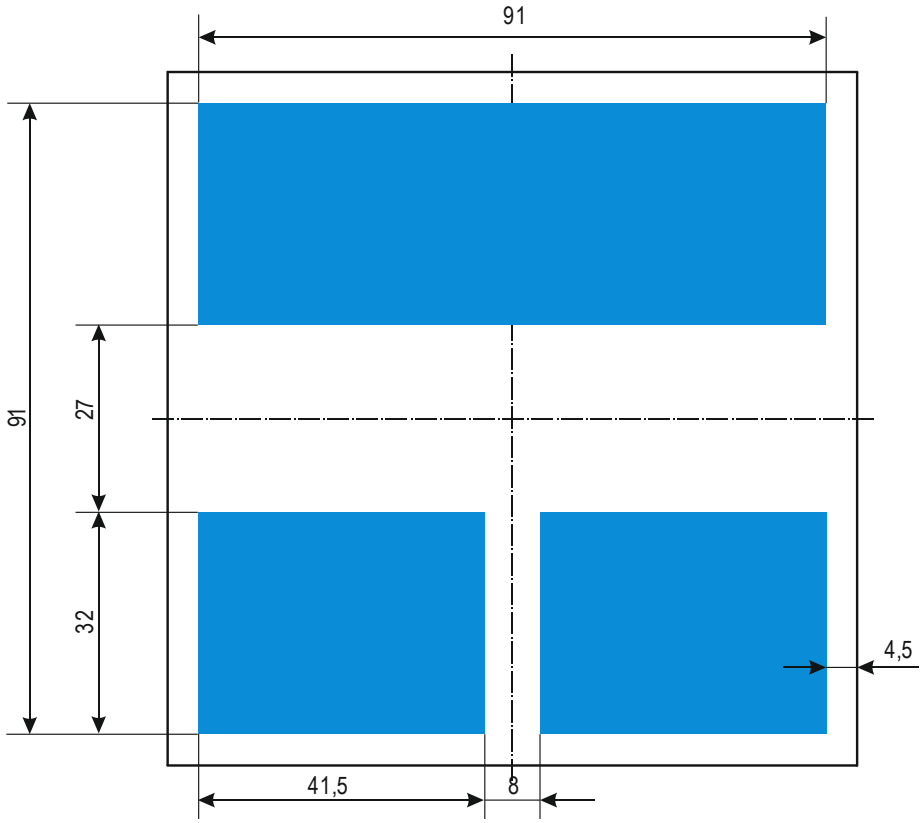

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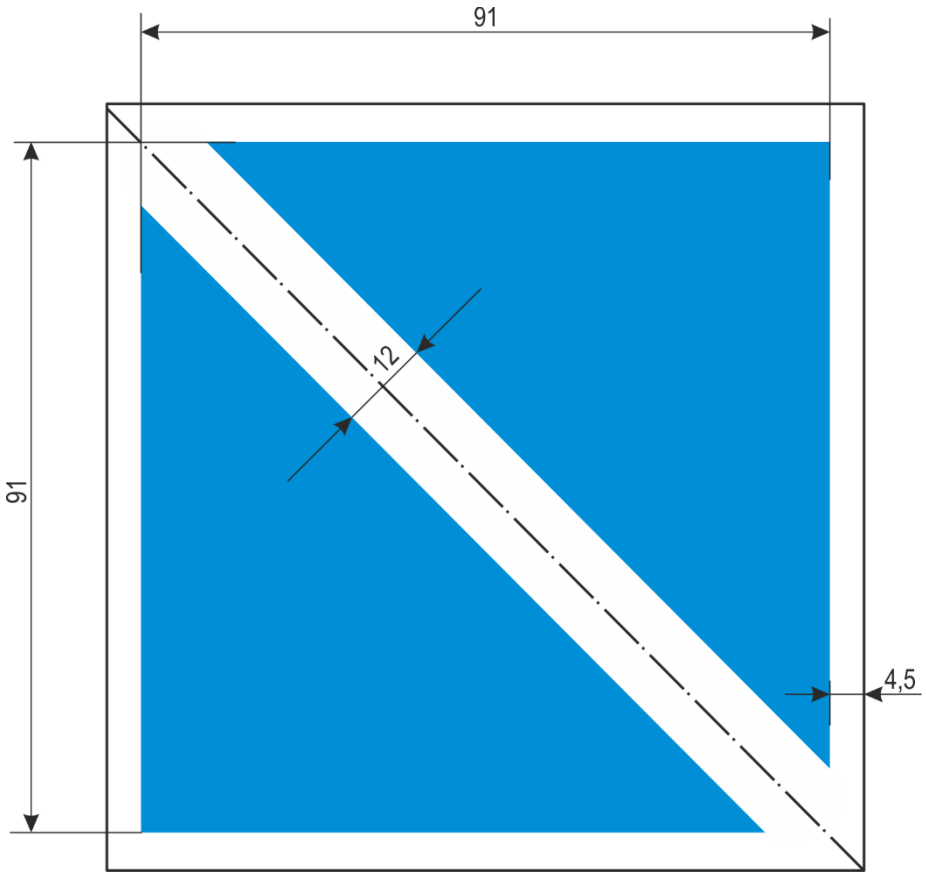

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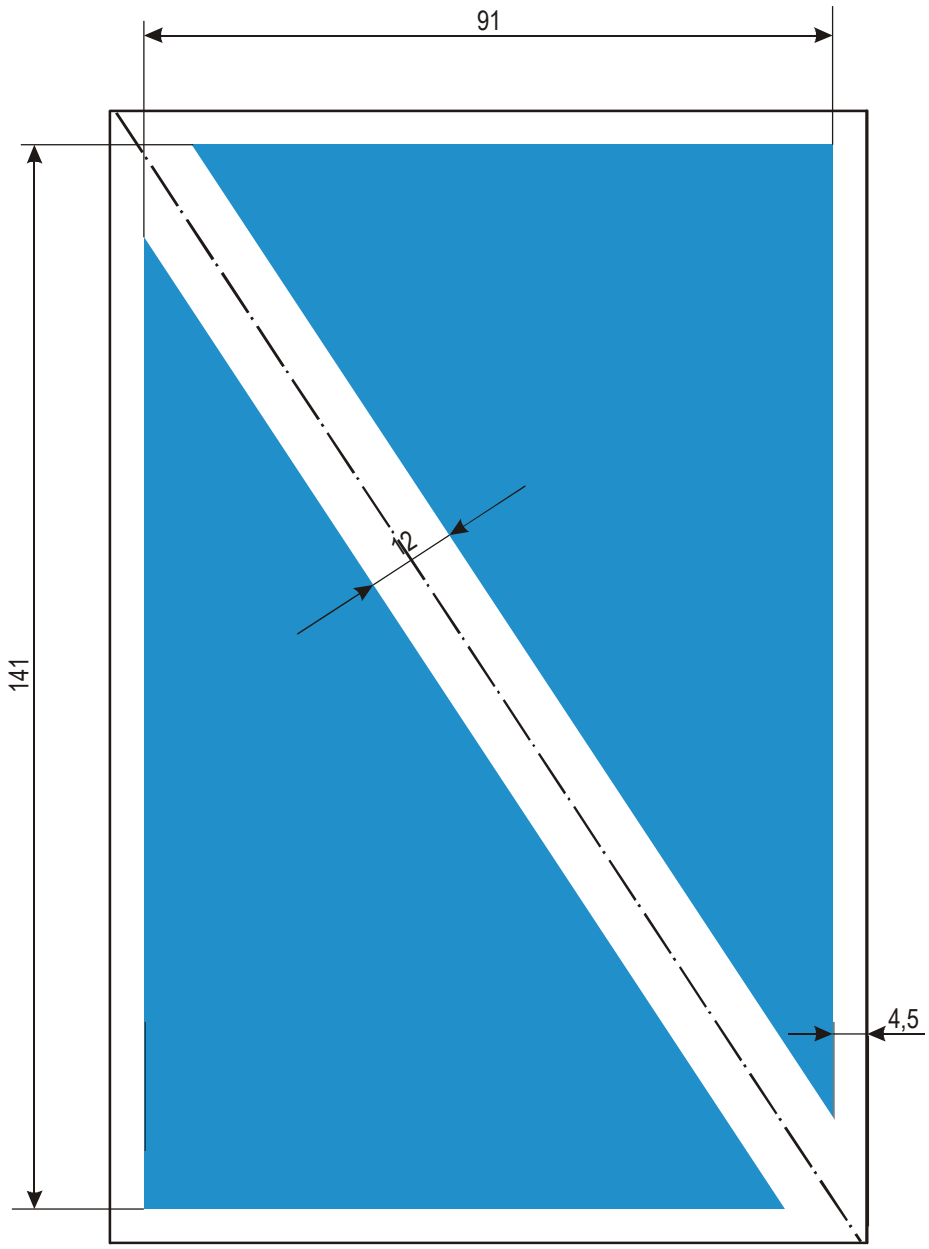

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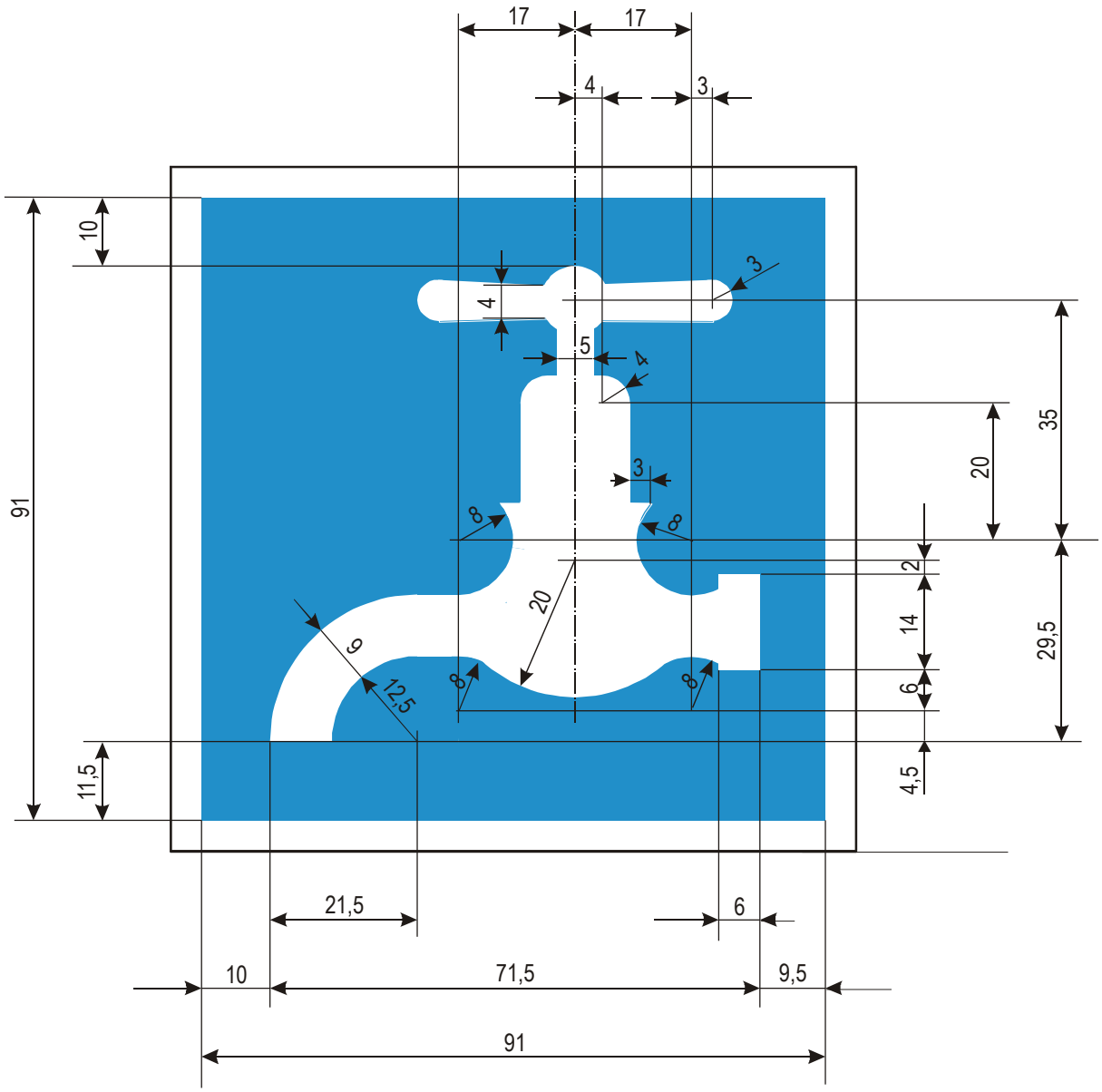
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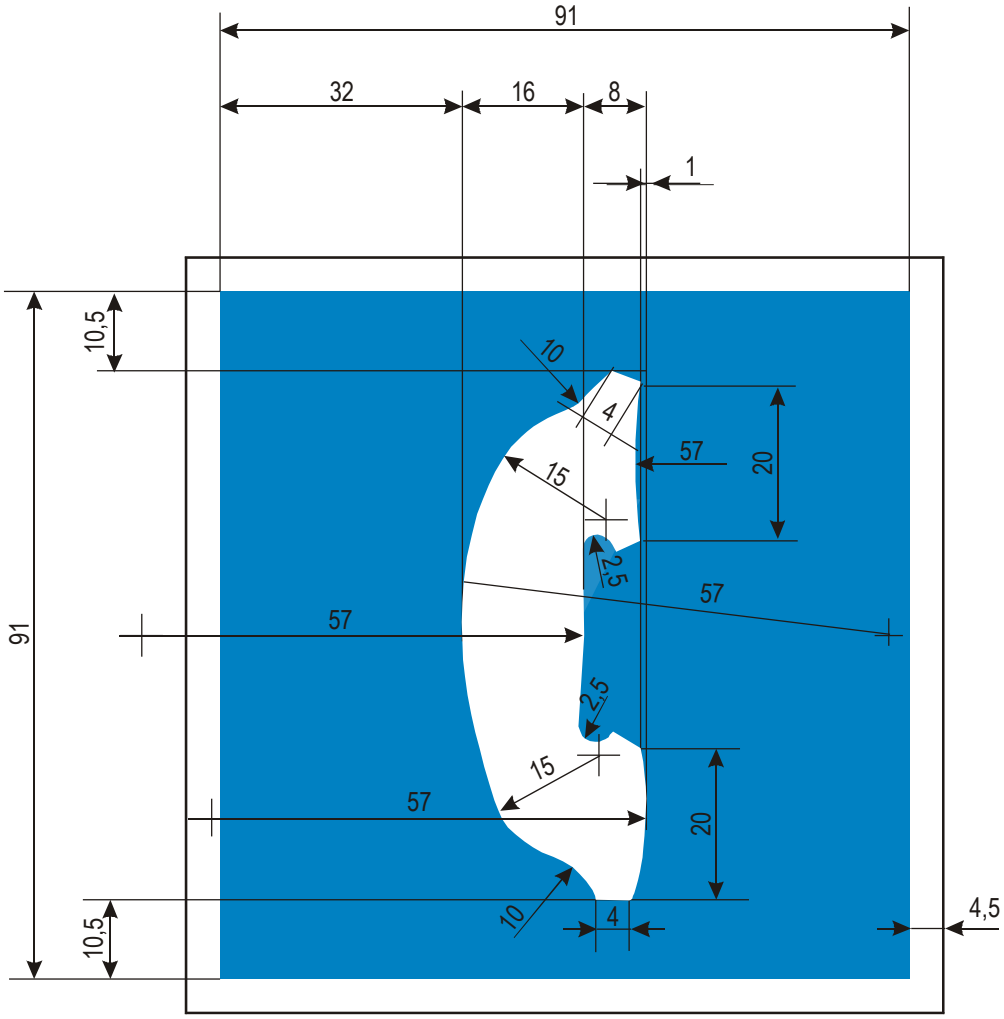
E. 14



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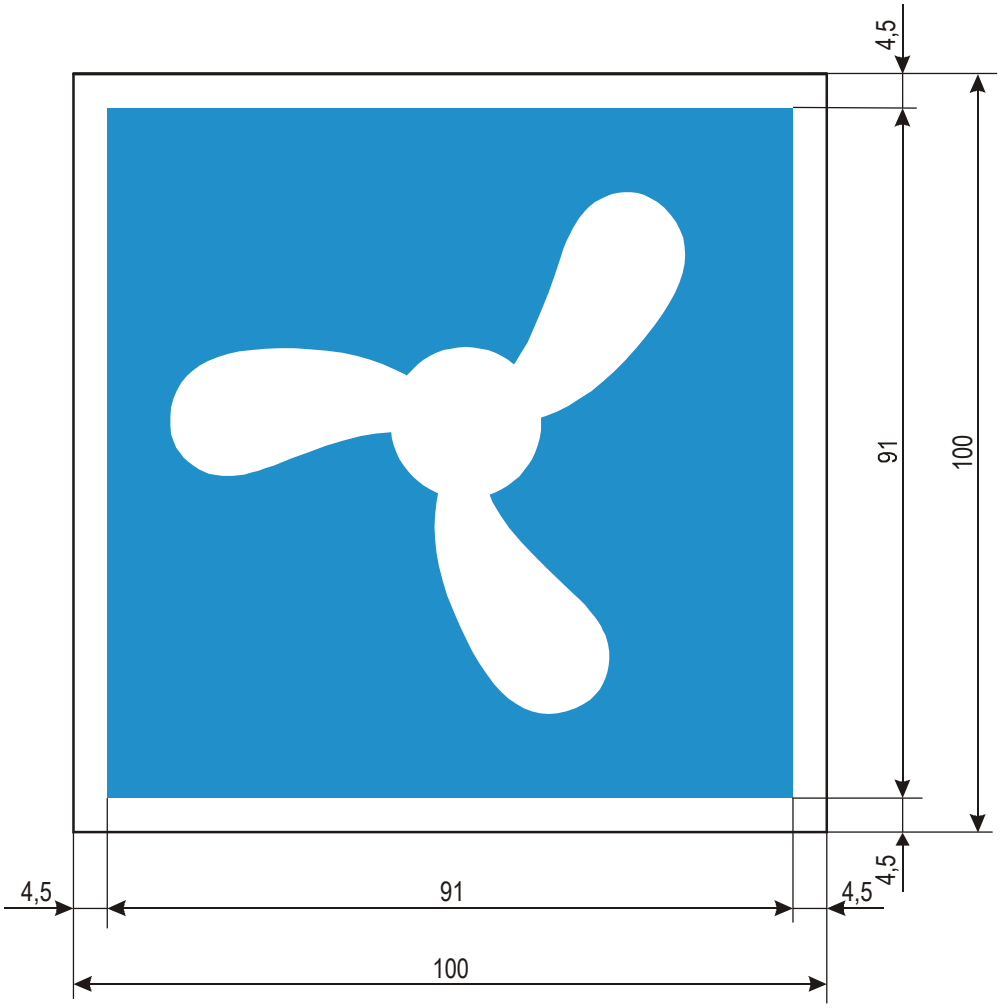

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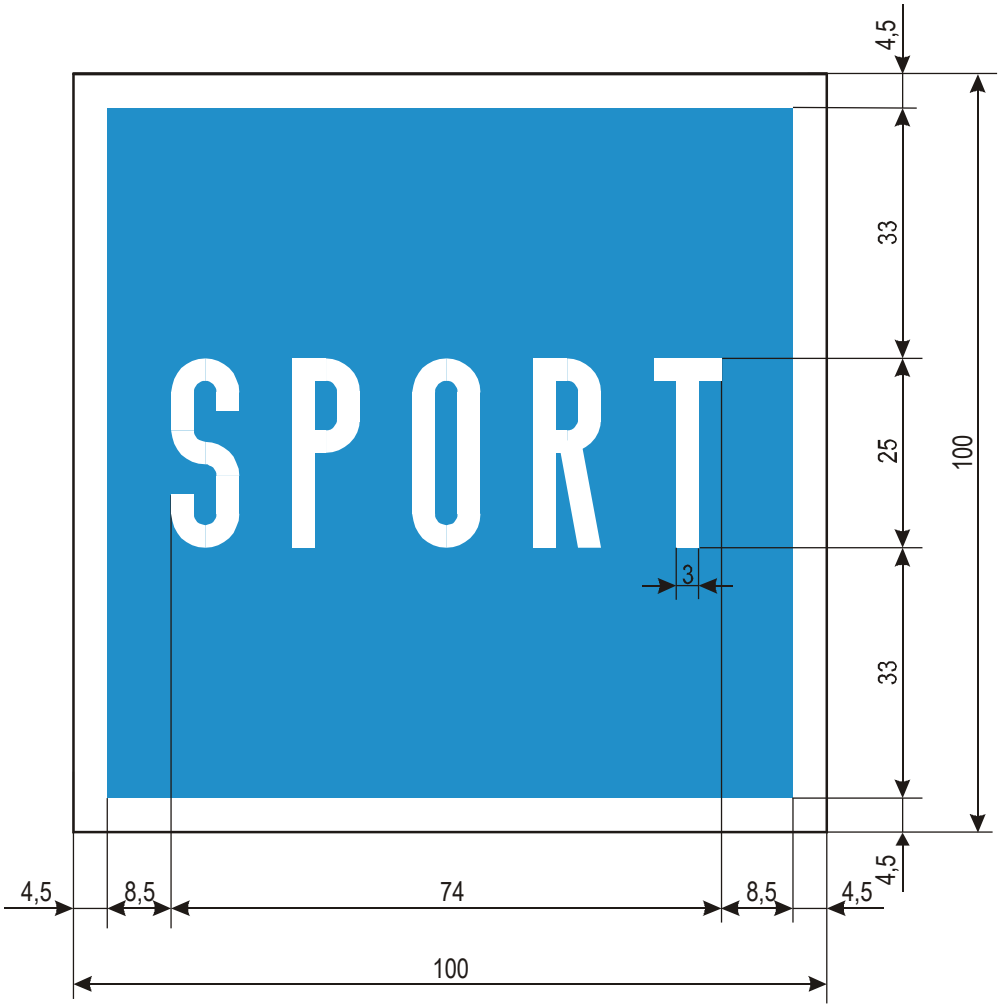

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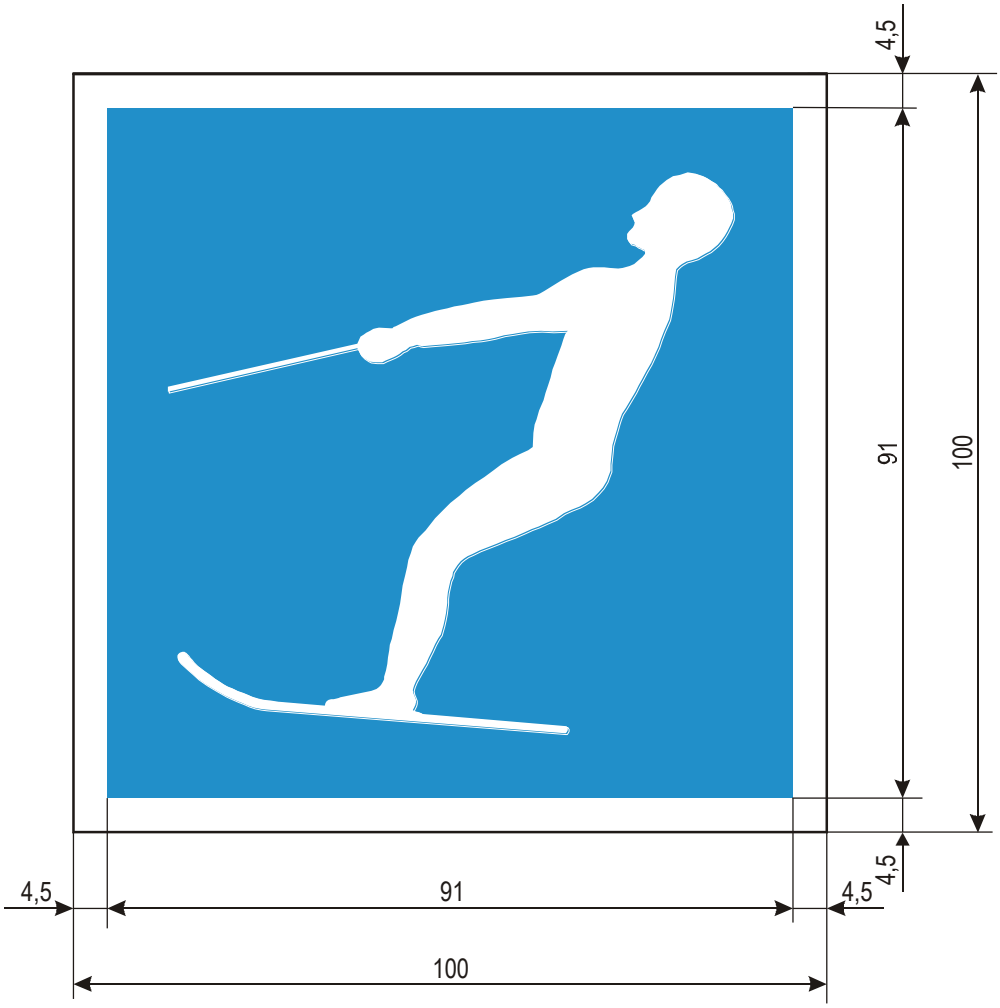

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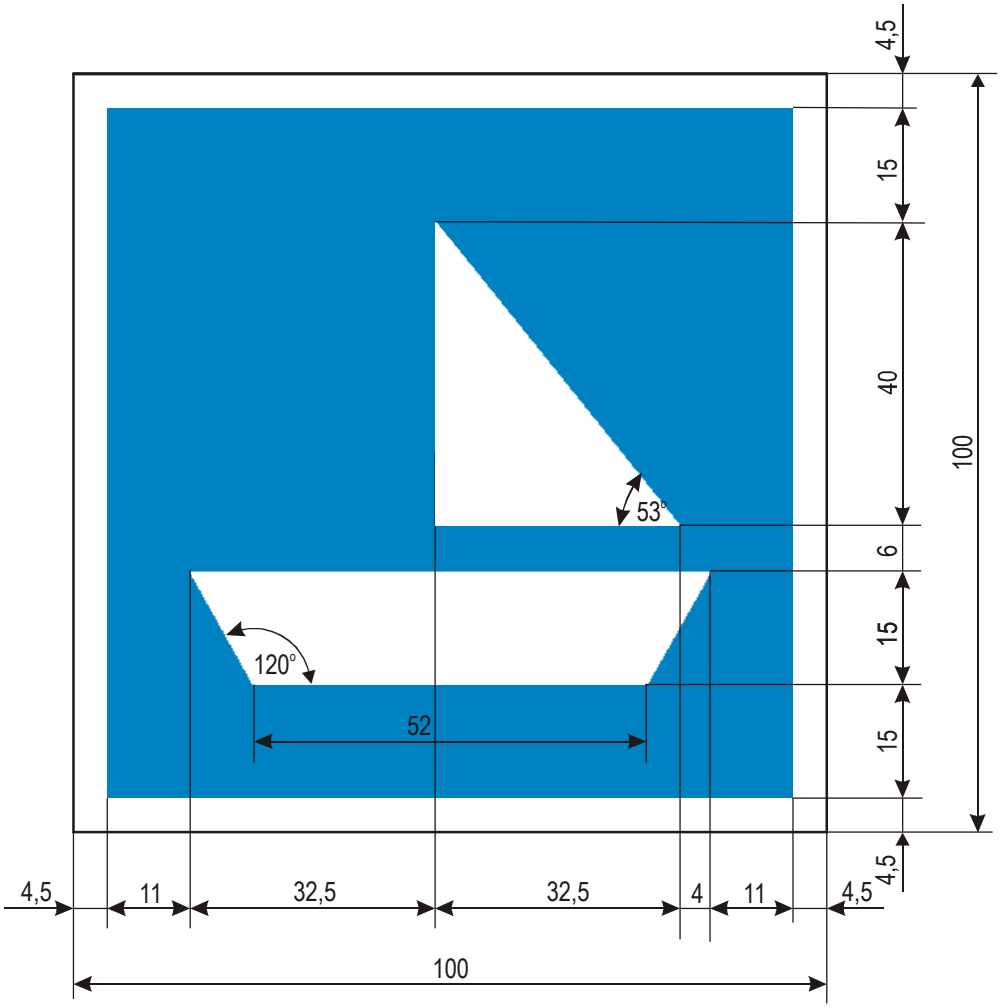

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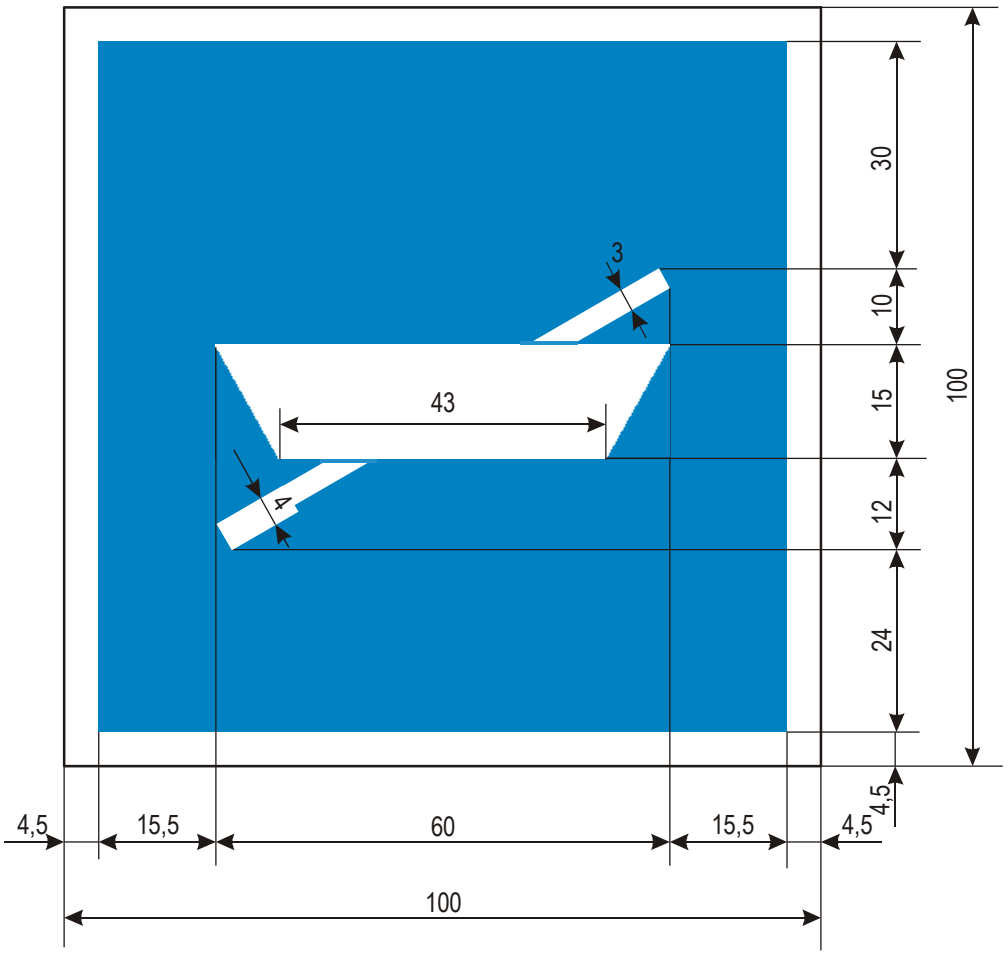

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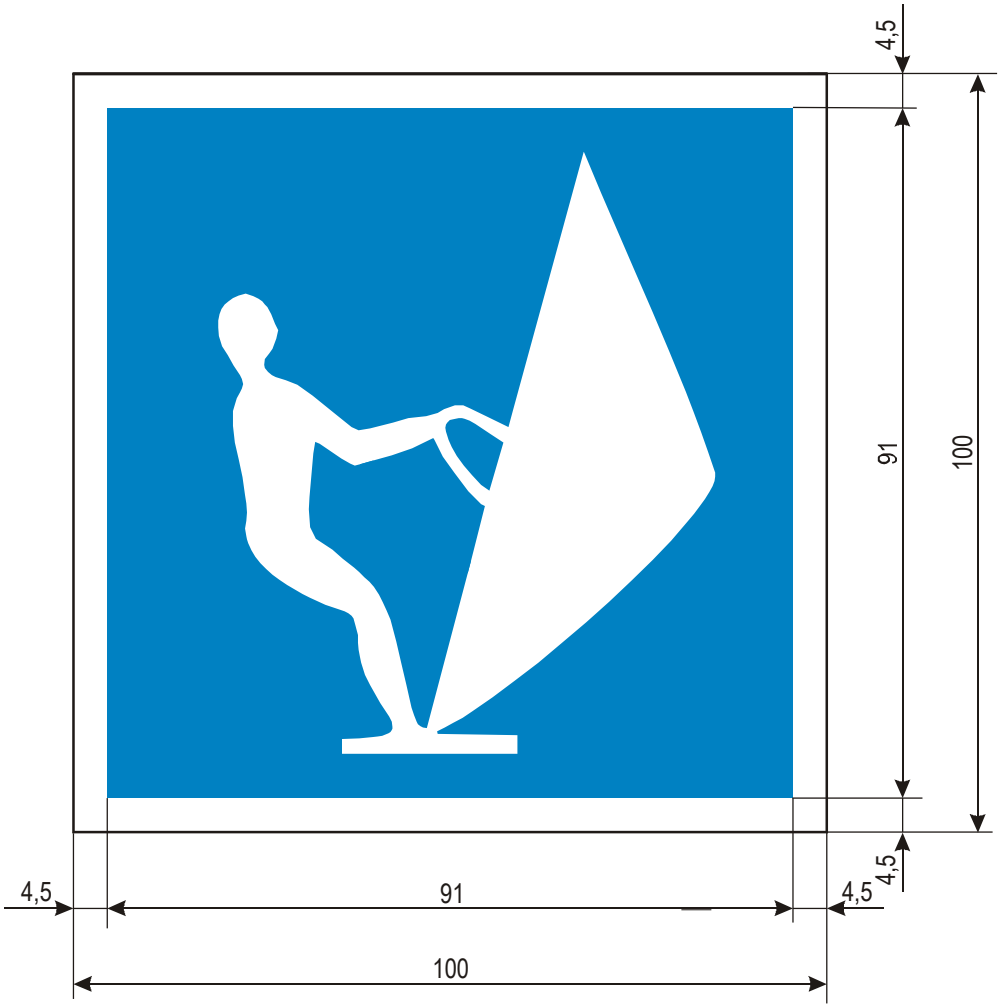

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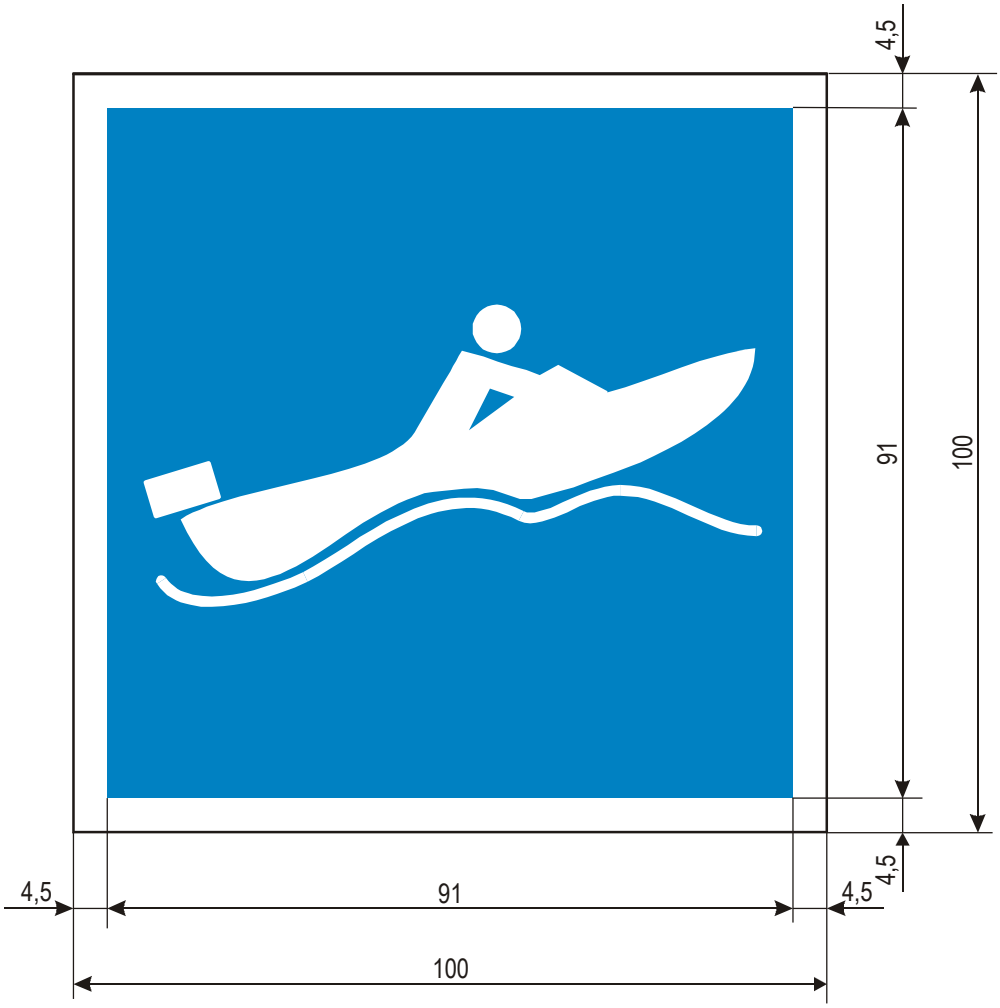

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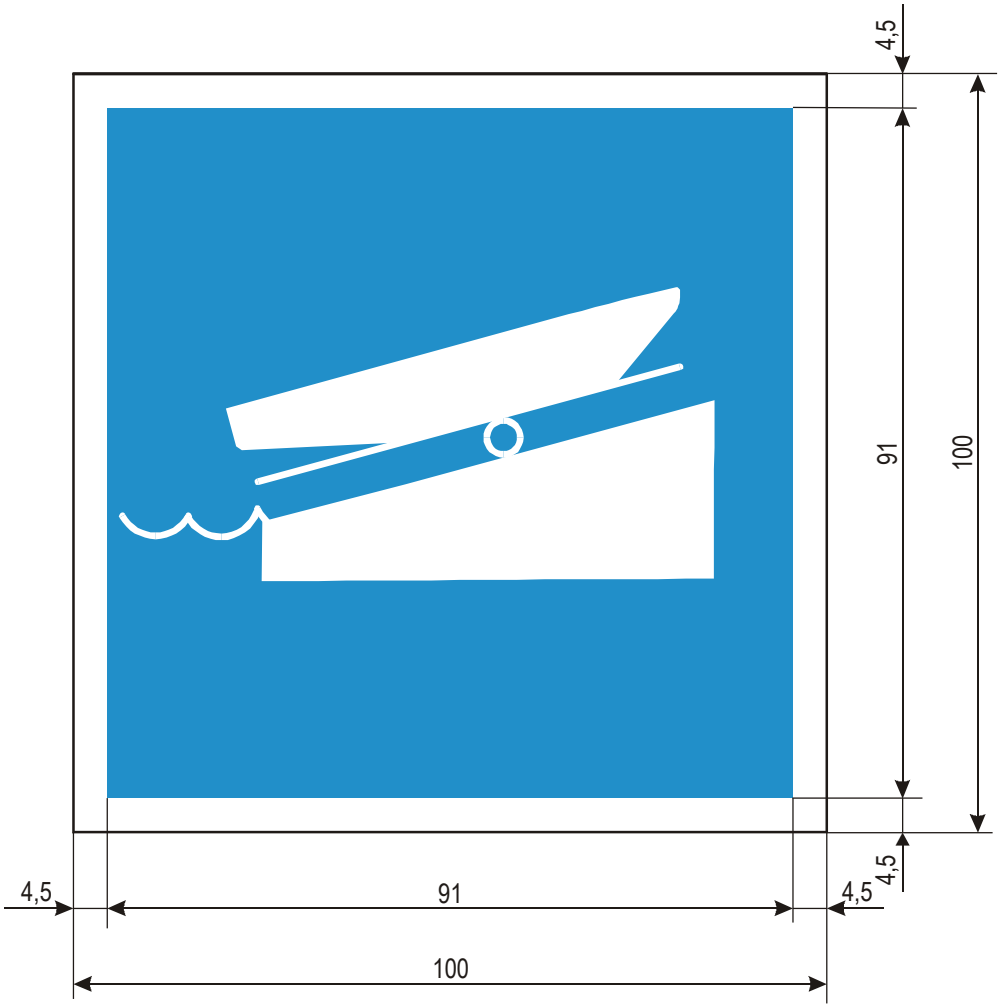

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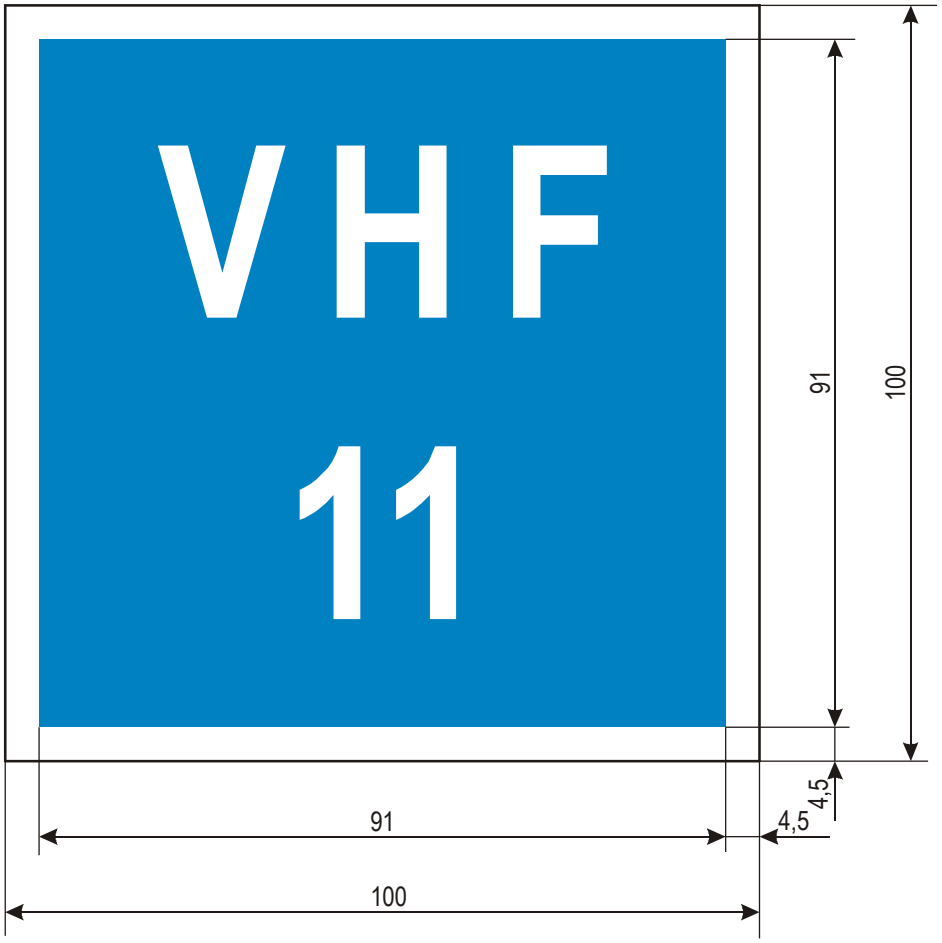

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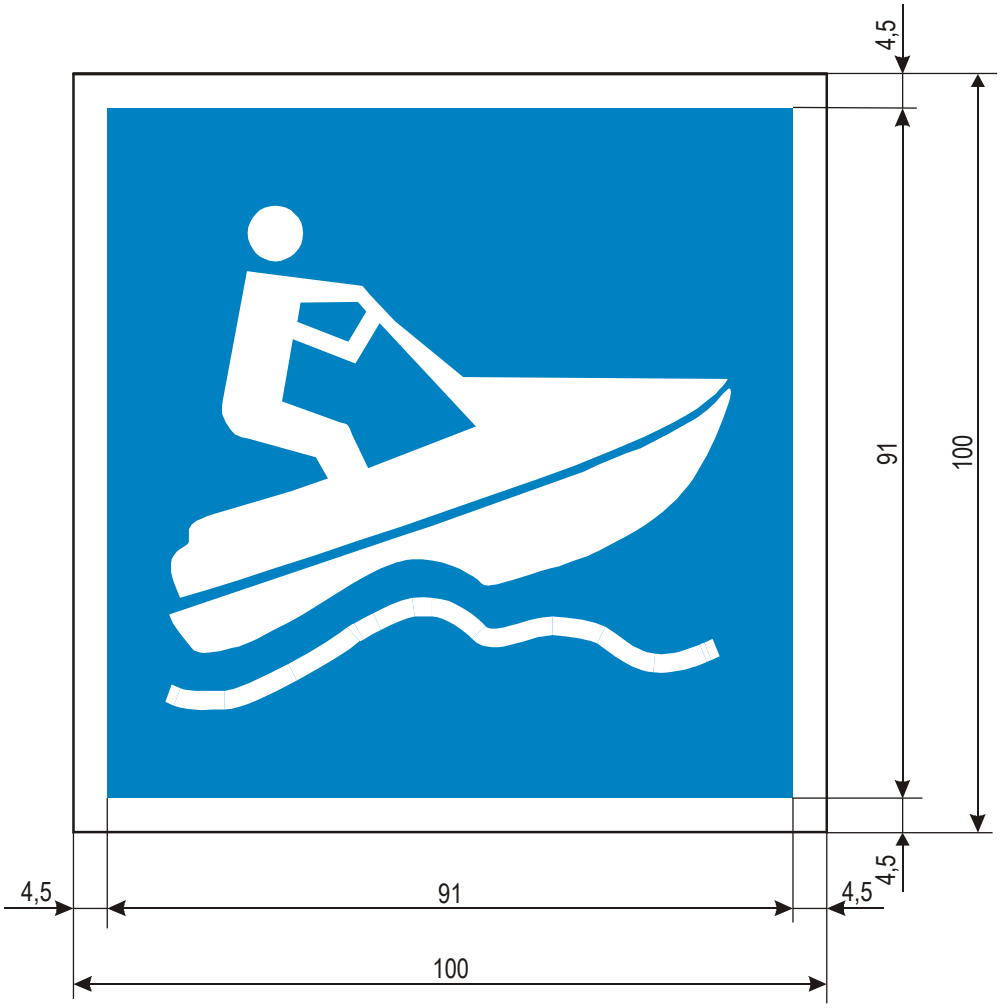

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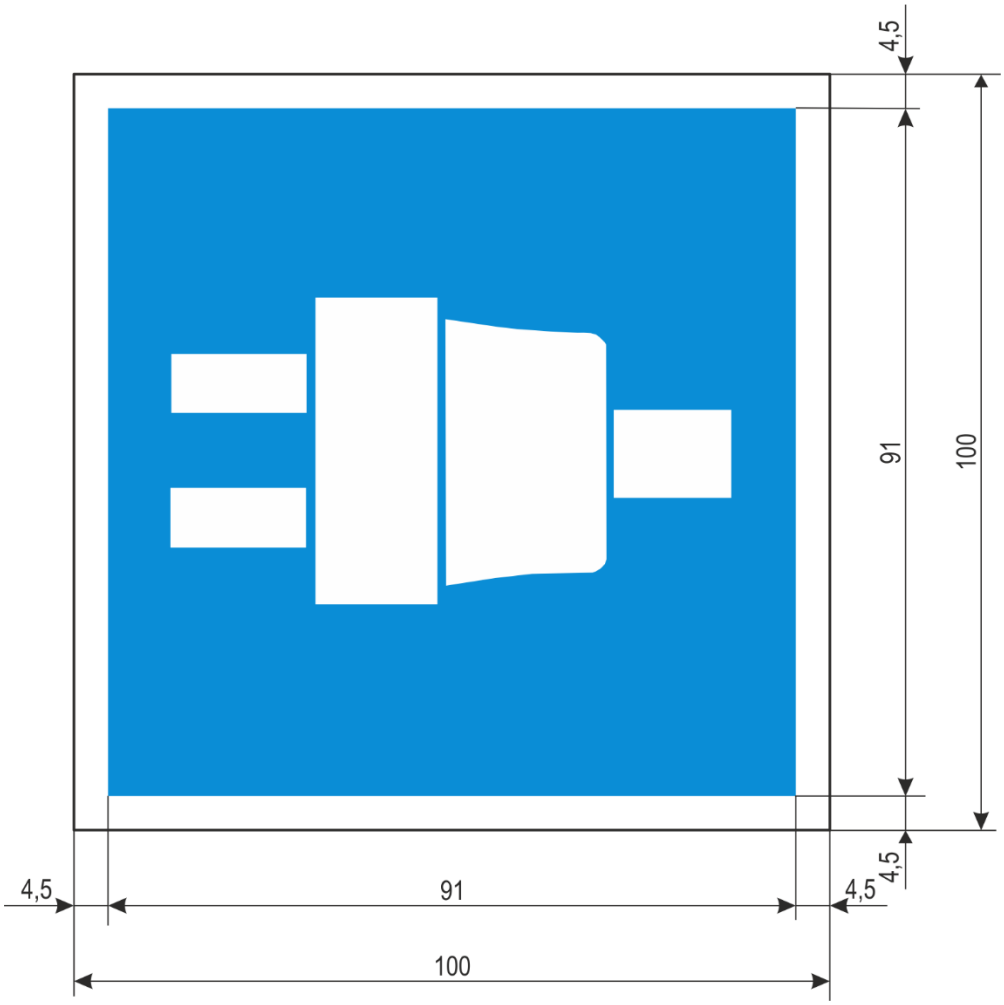

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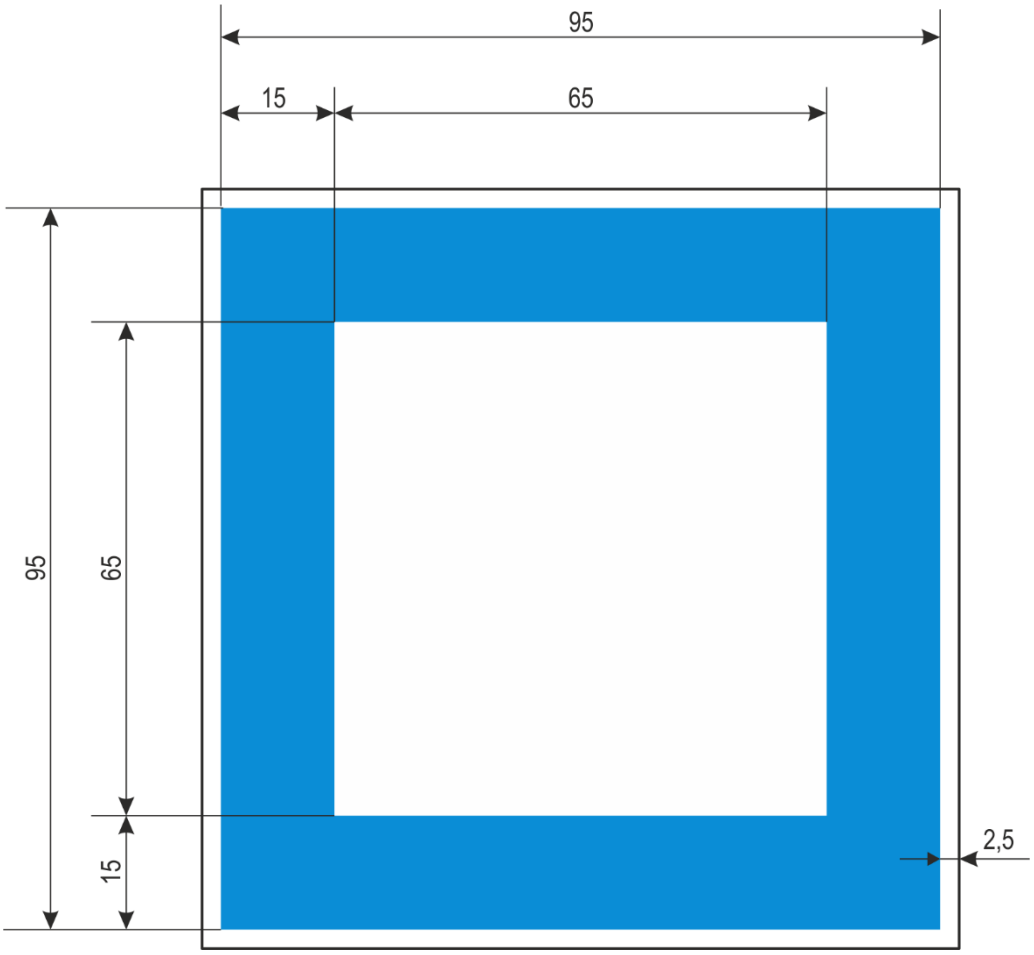

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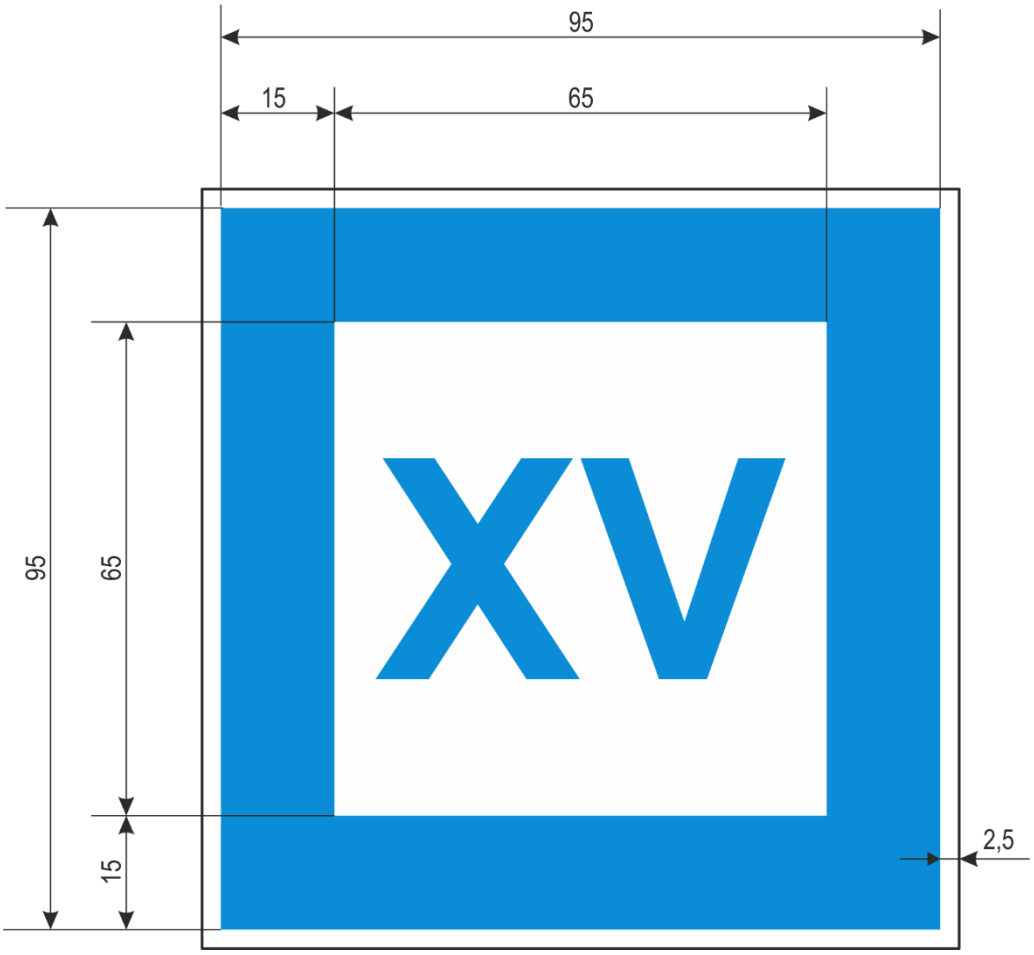

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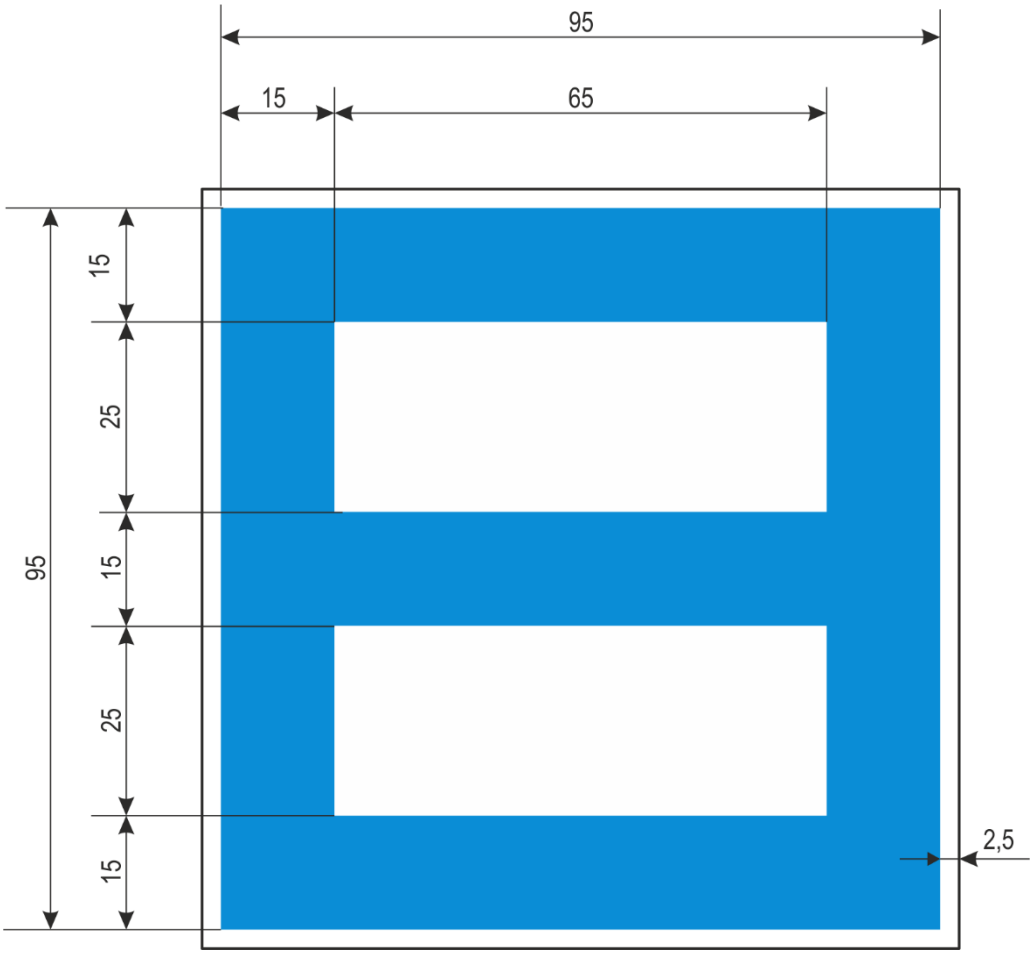

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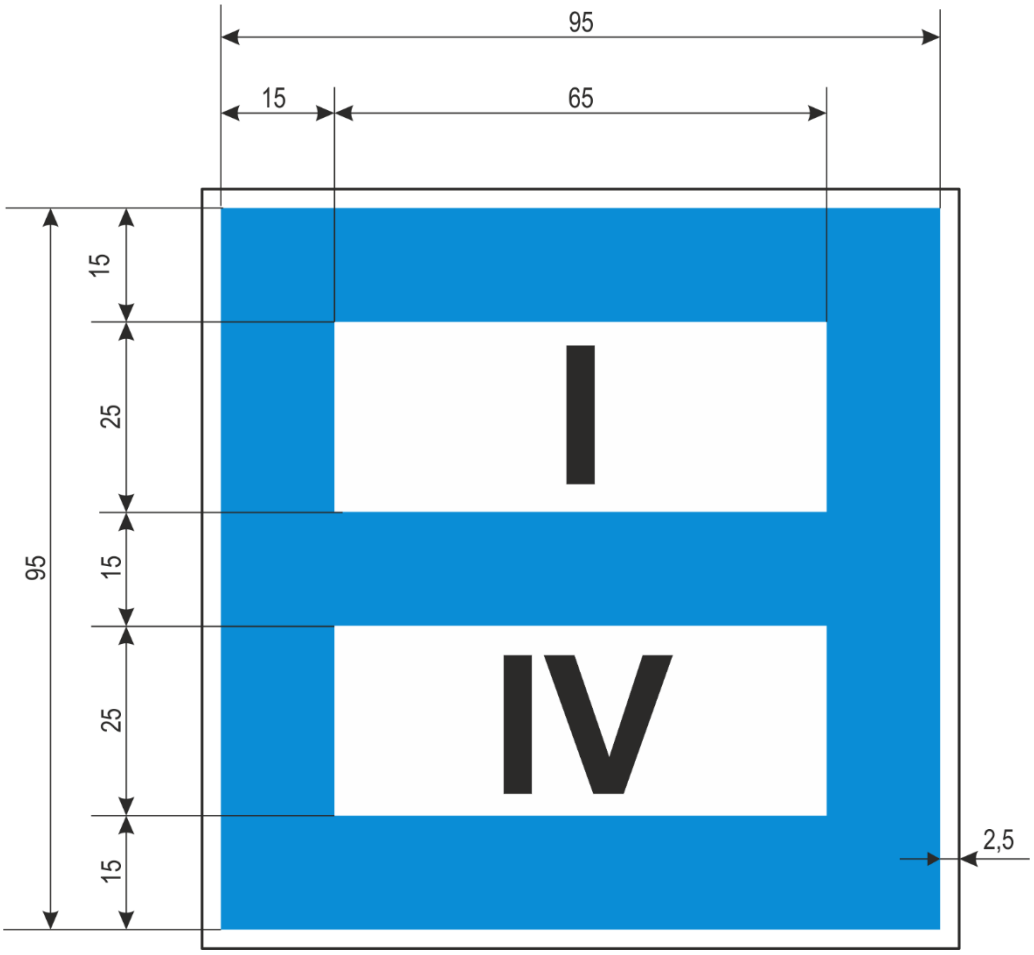

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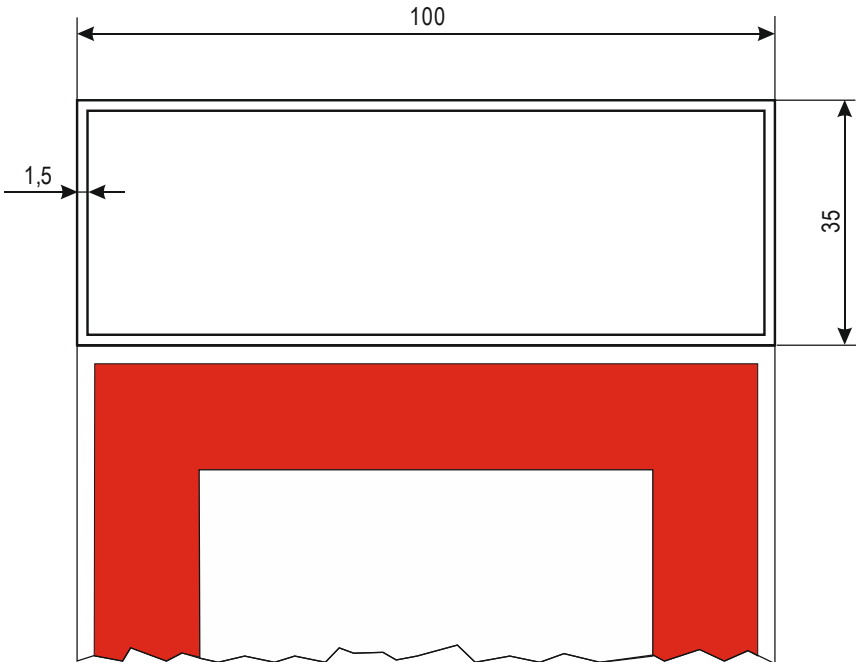

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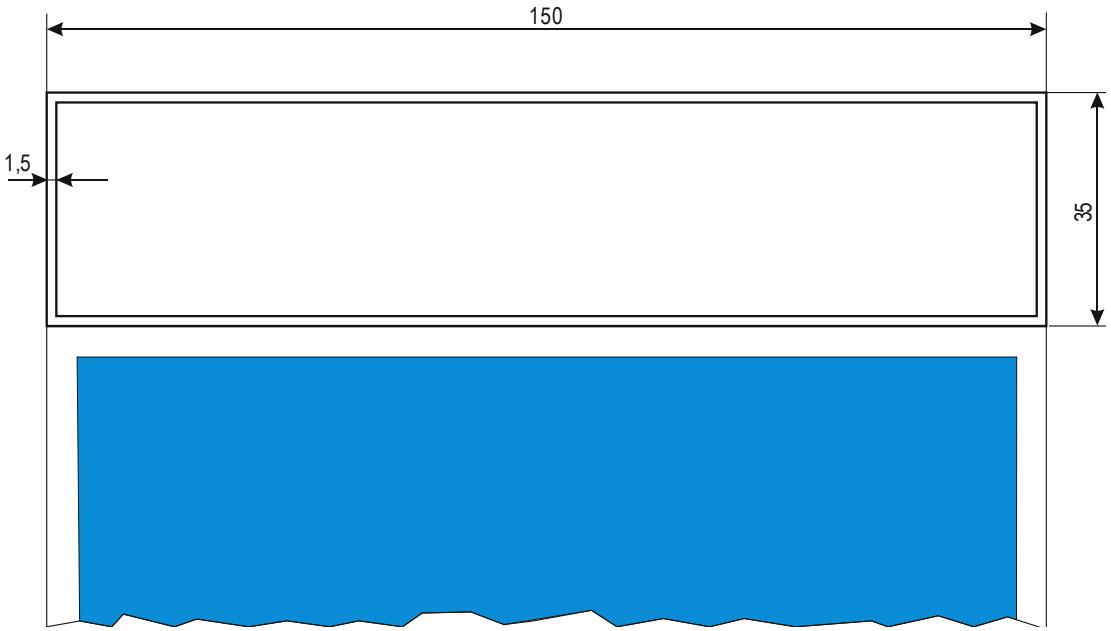

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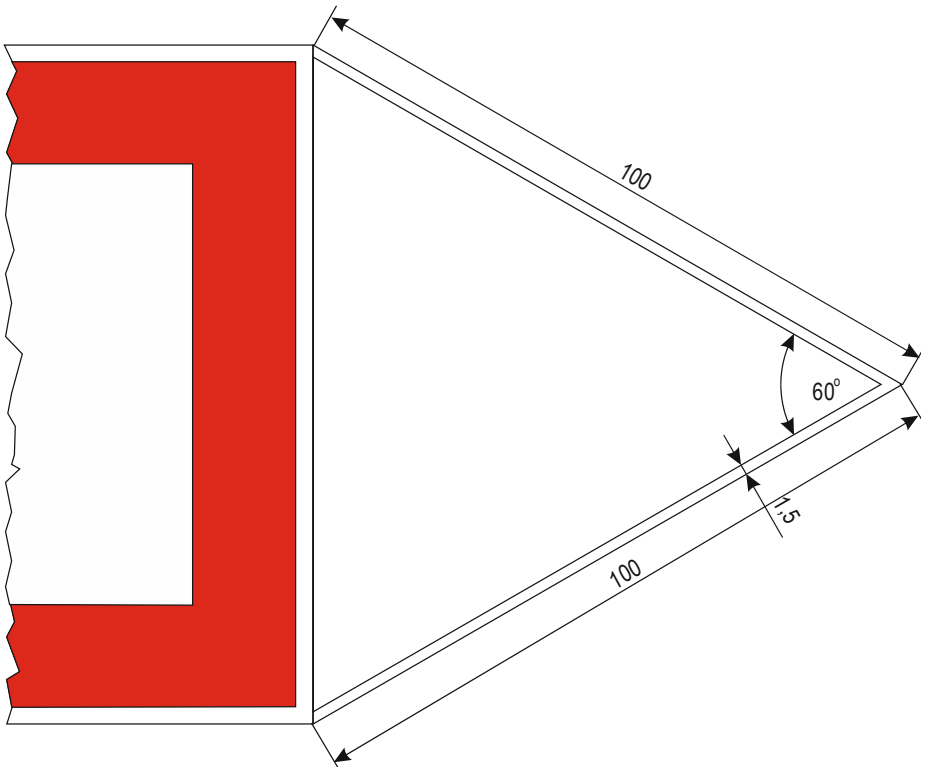

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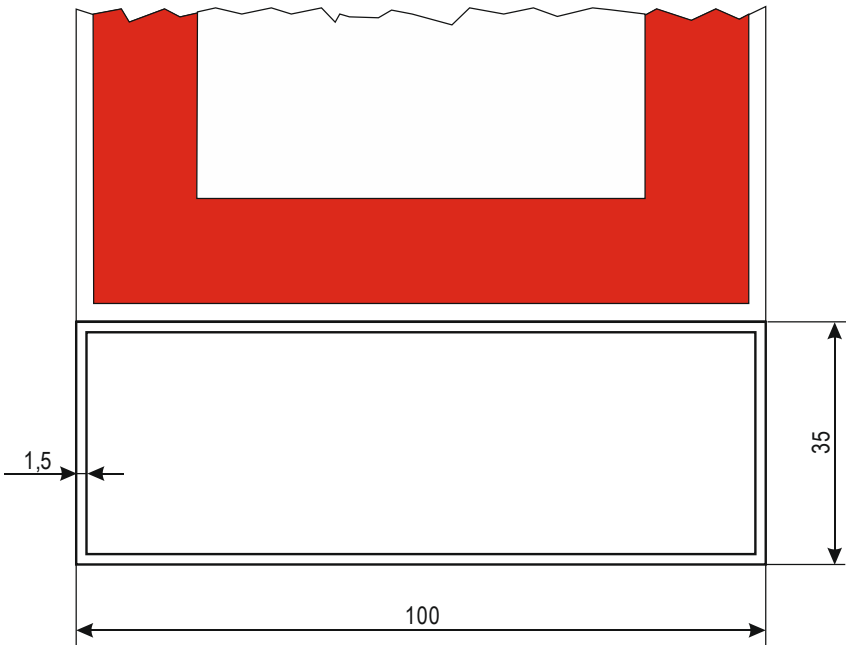
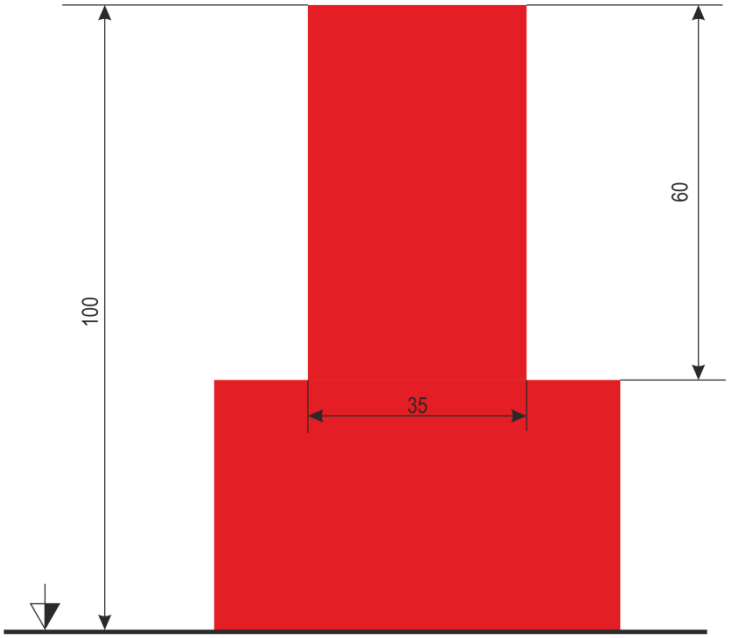


Signs contained in Annex 8 to DFND

1.C

Upstream of Gönyű



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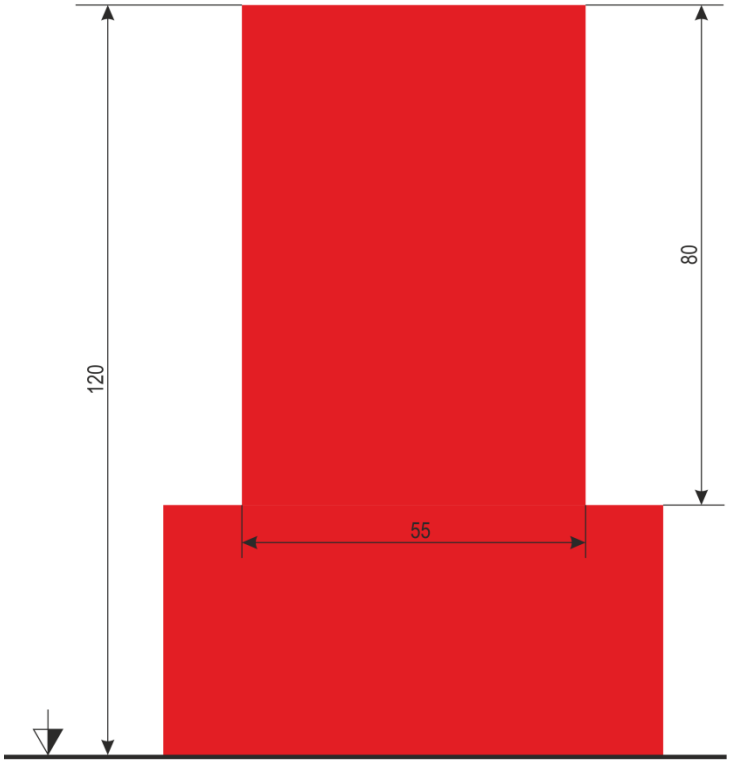
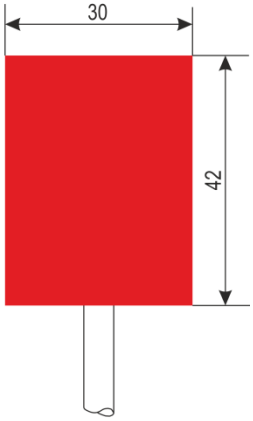


1.D

Marker post and spar



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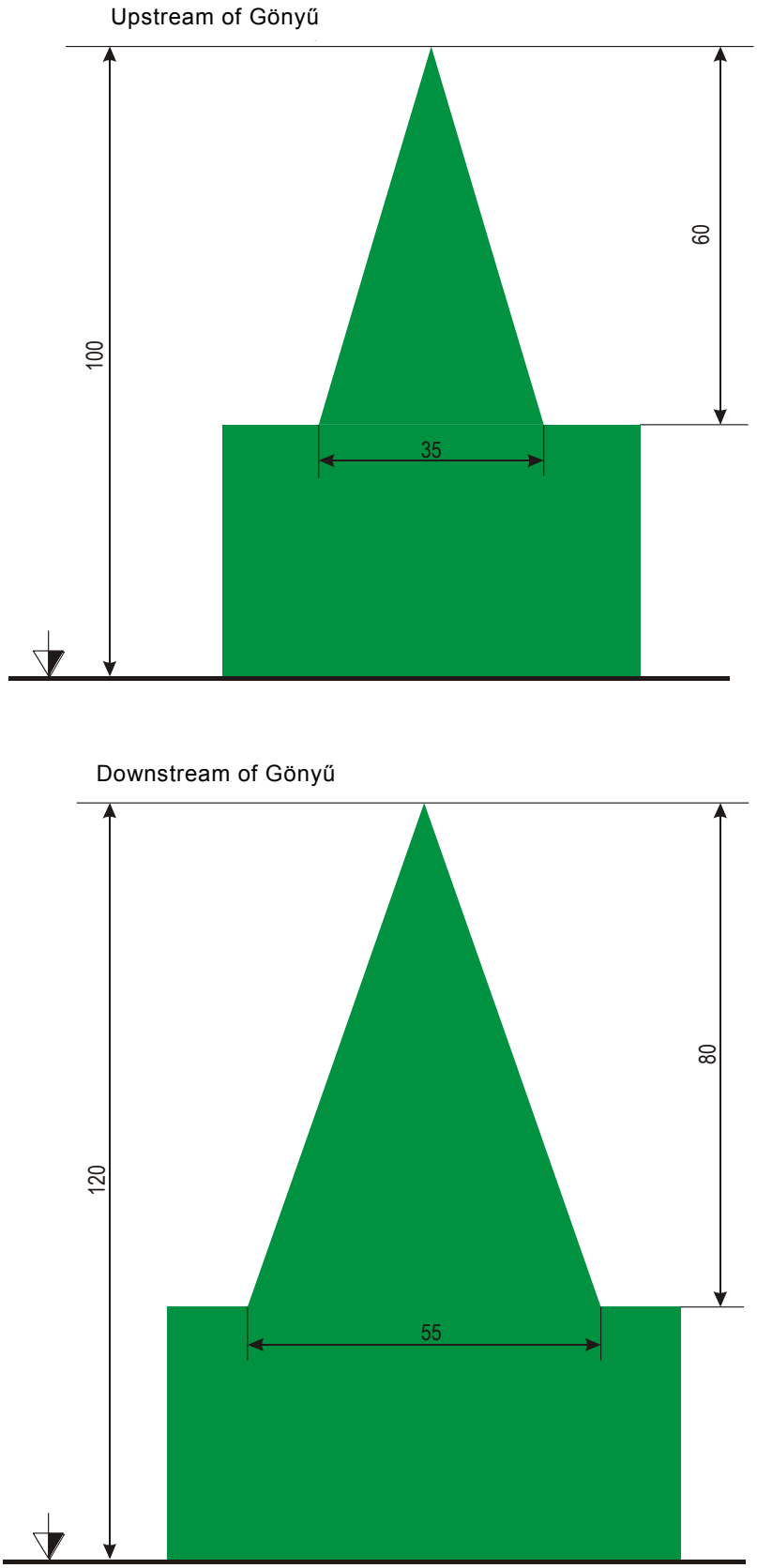
2.D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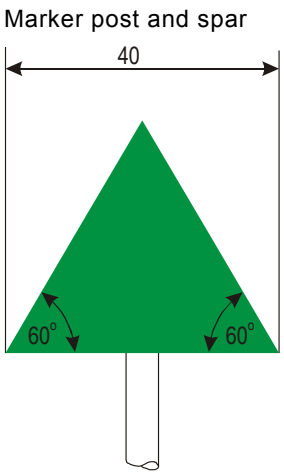
60
35
Downstream of Gönyű
120
80
55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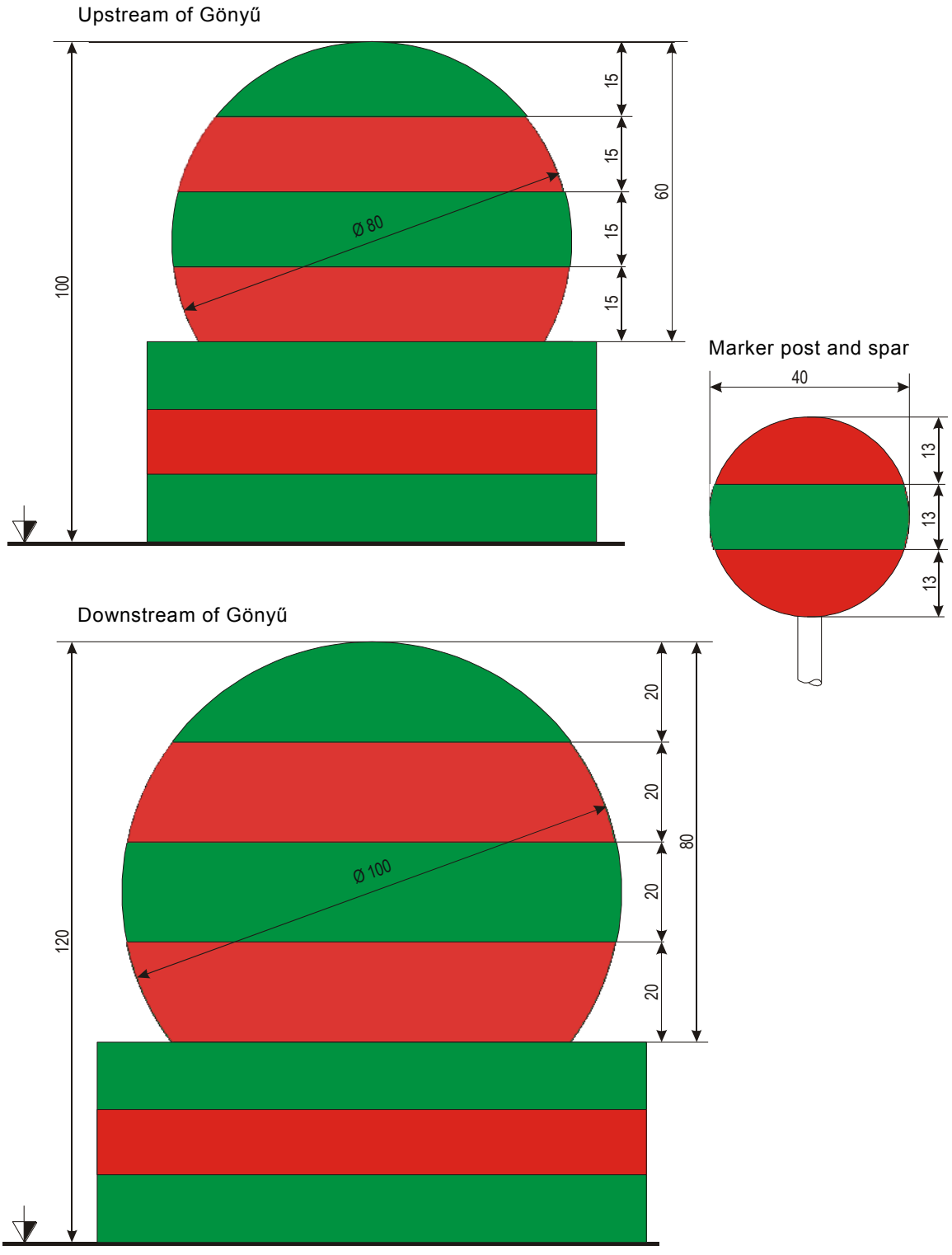
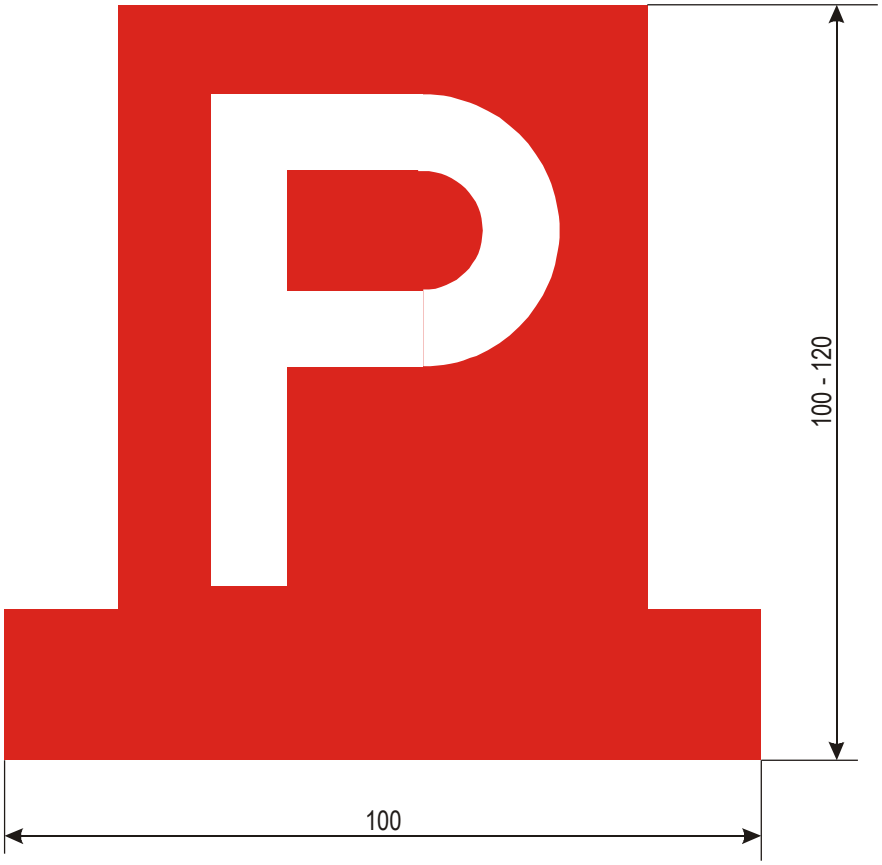
60°
60°

3.C 3.D


Upstream of Gönyű
100
Ø 80
15
15
15
15
60
Marker post and spar
40
13
13
13
Downstream of Gönyű
120
Ø 100
20
20
20
20
80

4.a



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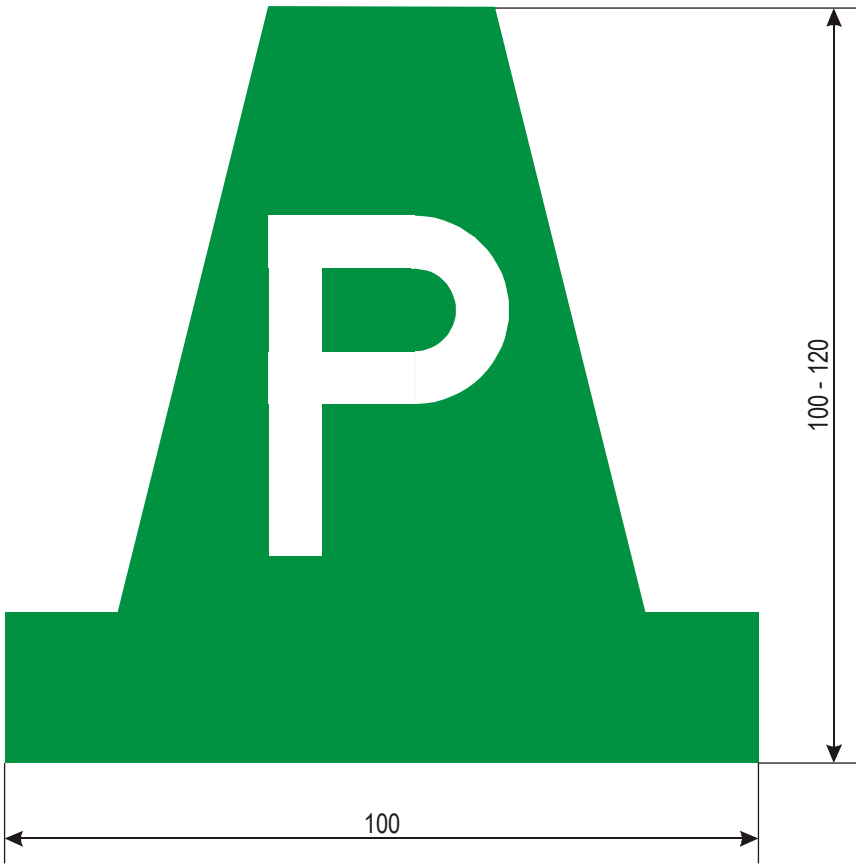

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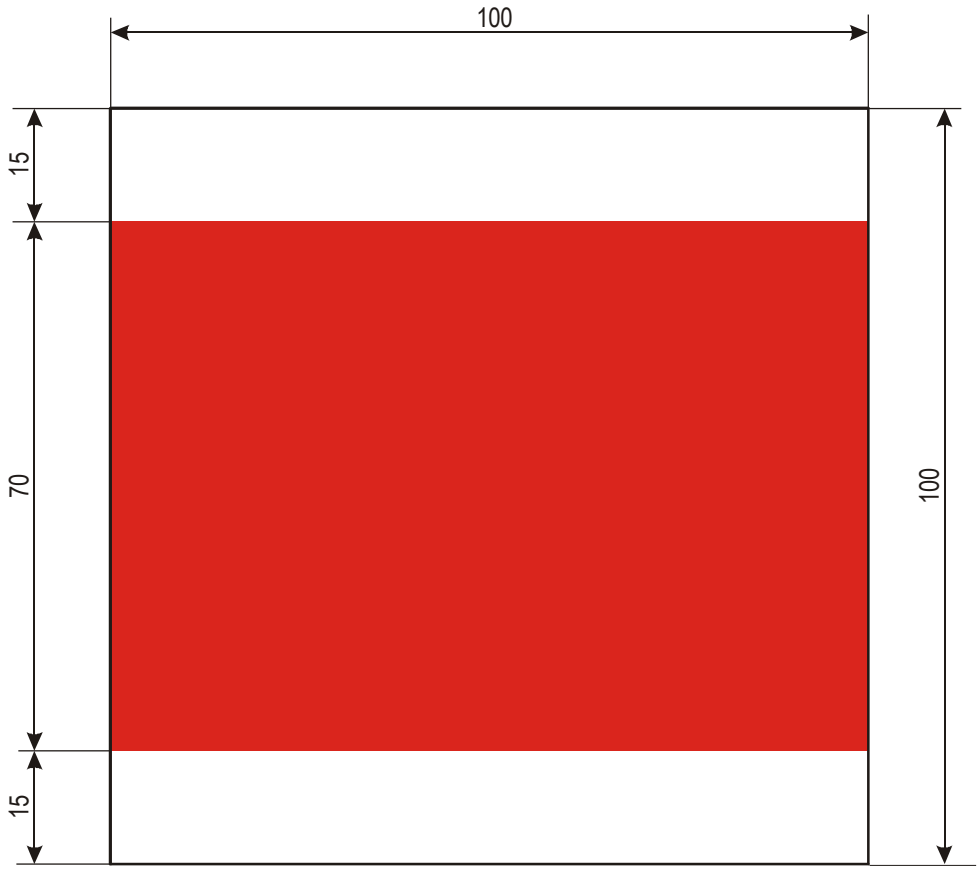

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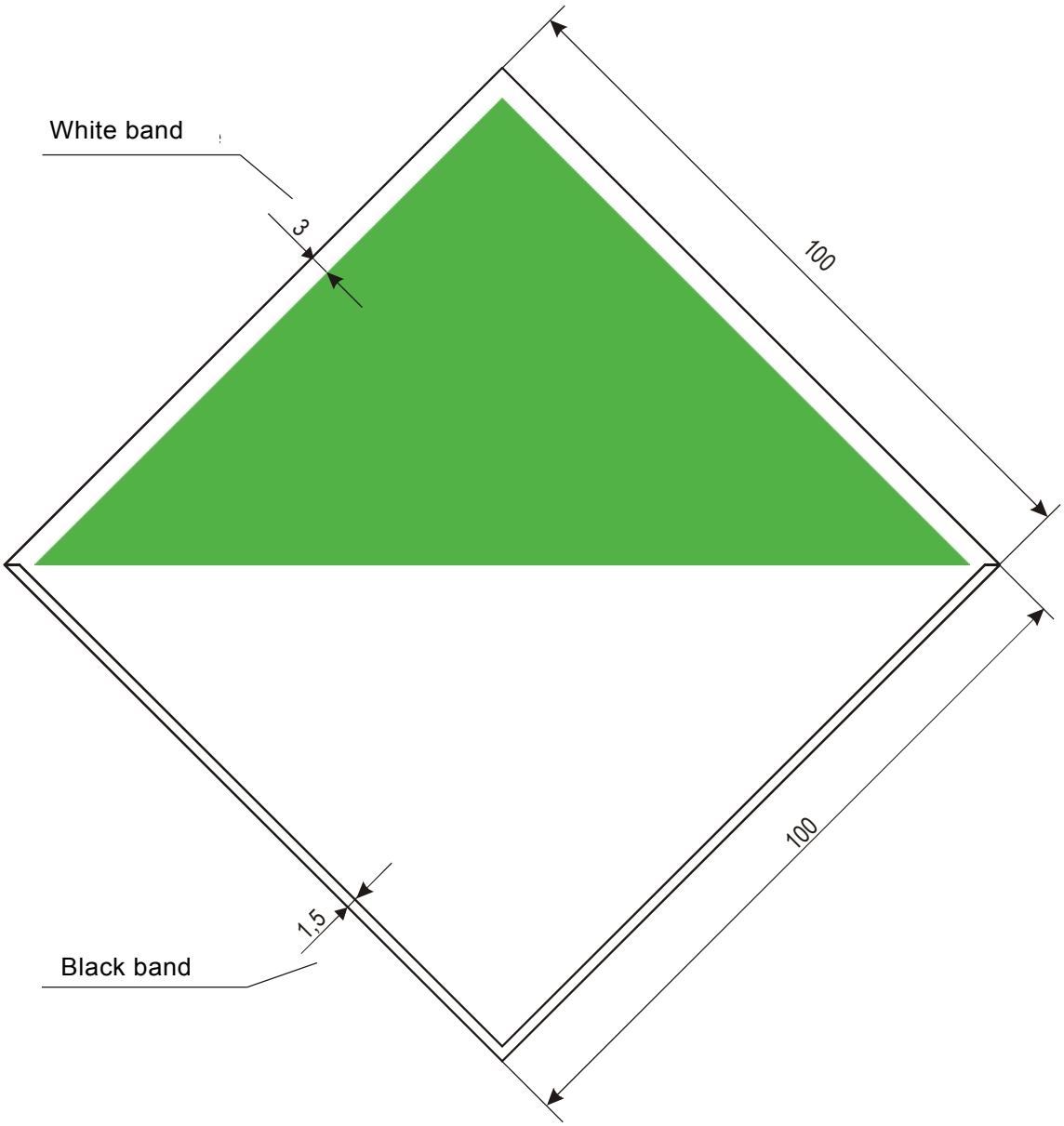
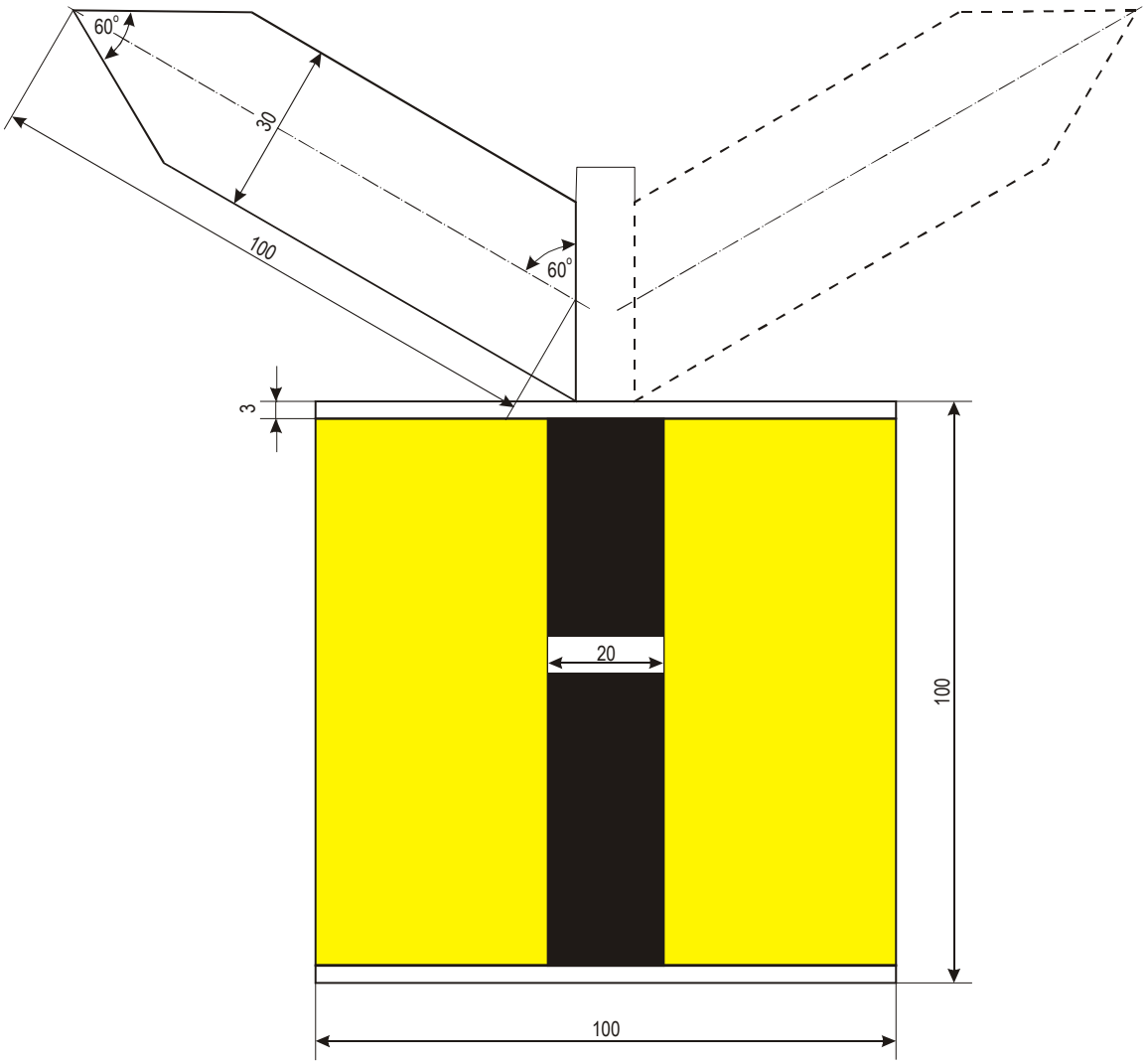
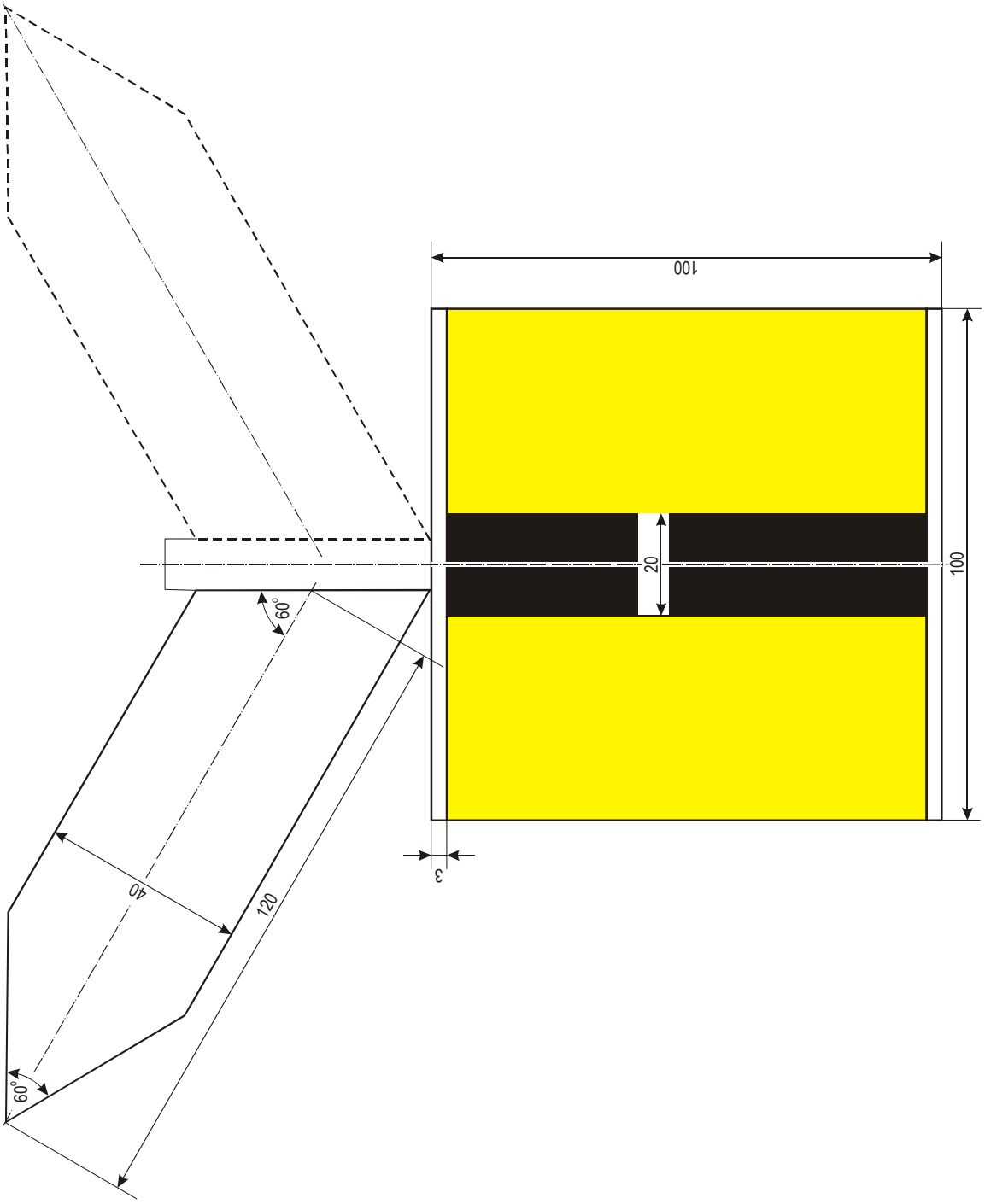


4.D

Upstream from Gönyű



Downstream from Gönyű



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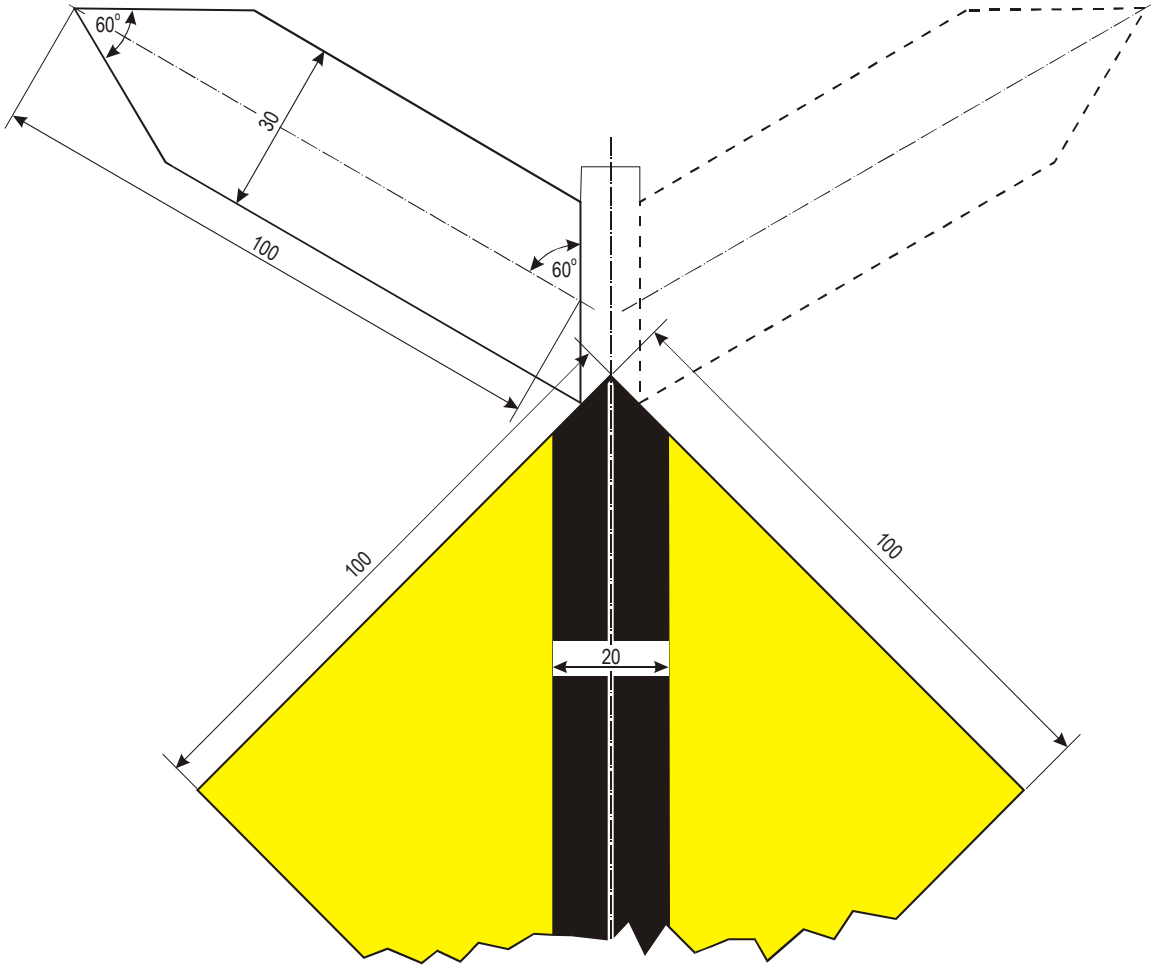
Upstream from Gönyű



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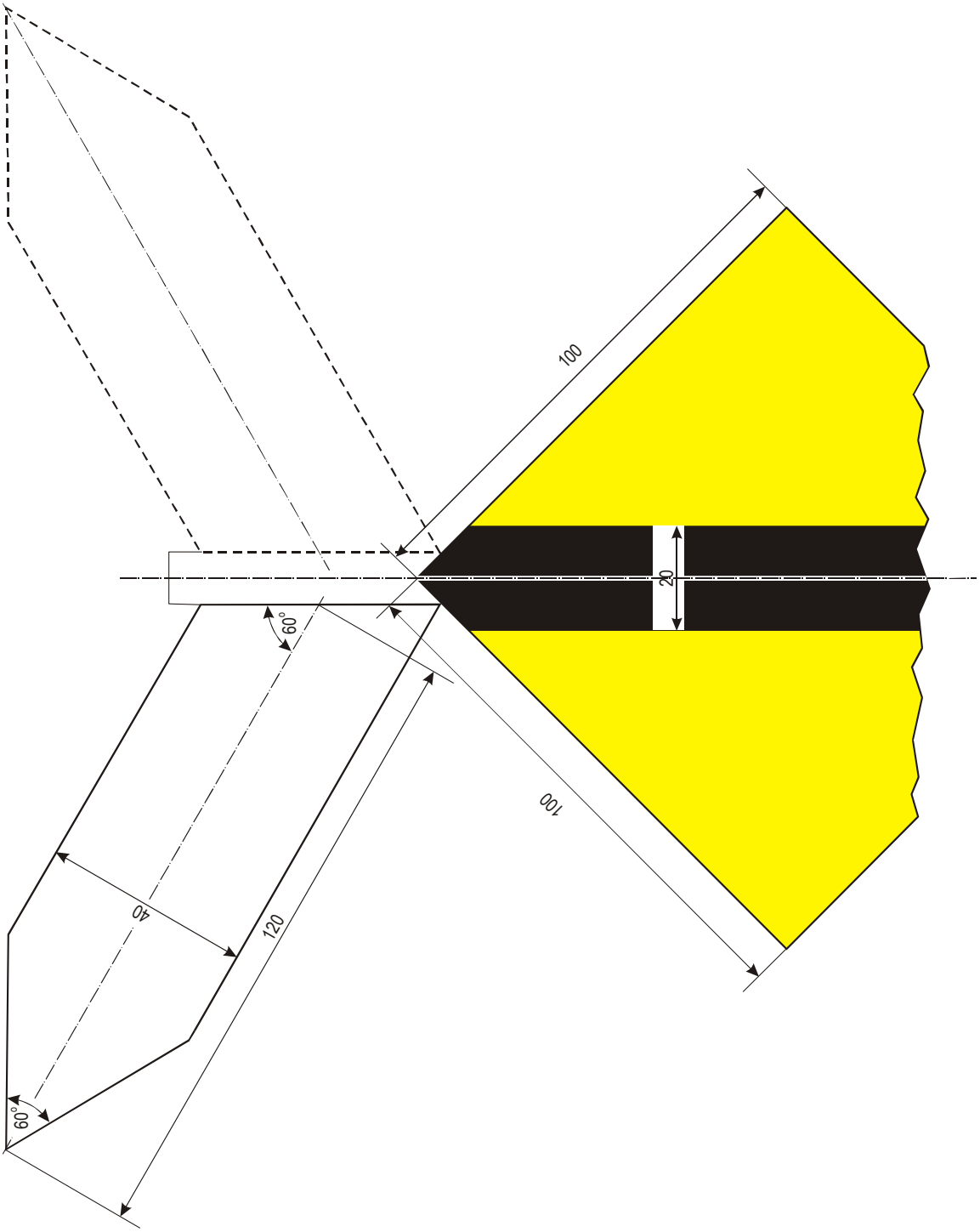
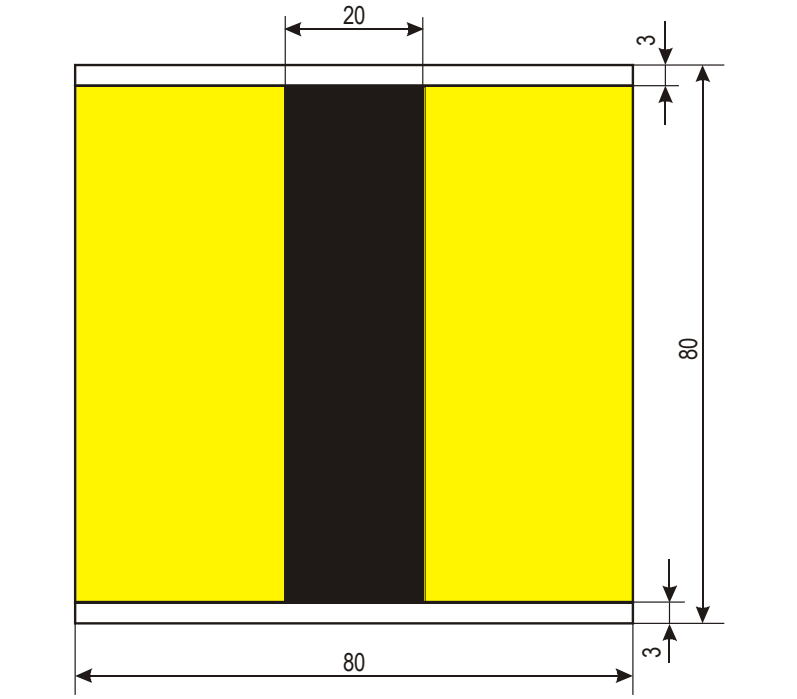
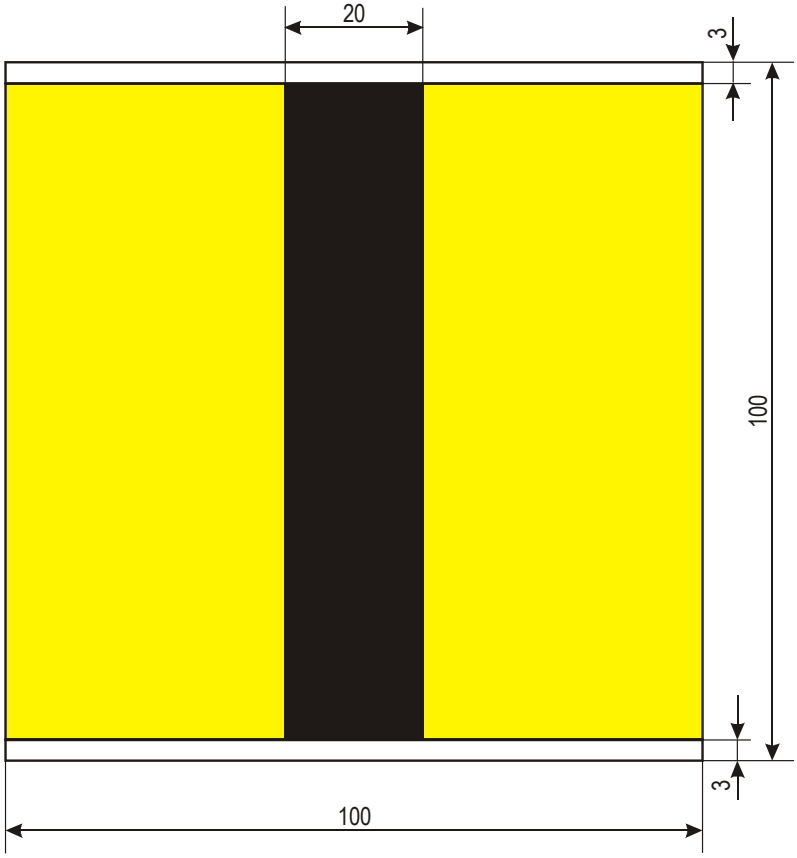
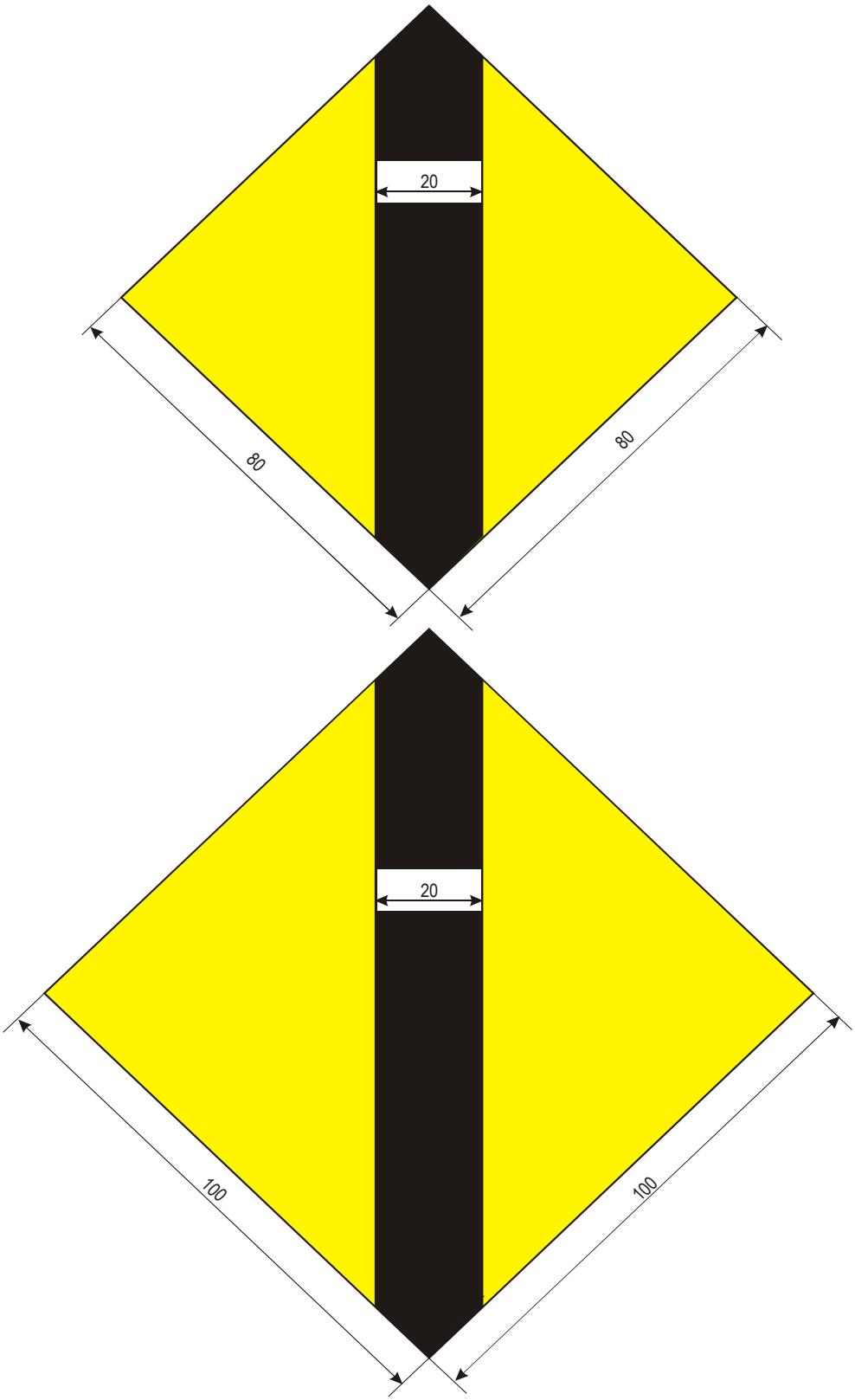


Annex 8 — III. B.3.2





Annex 8 — III. B.3.2



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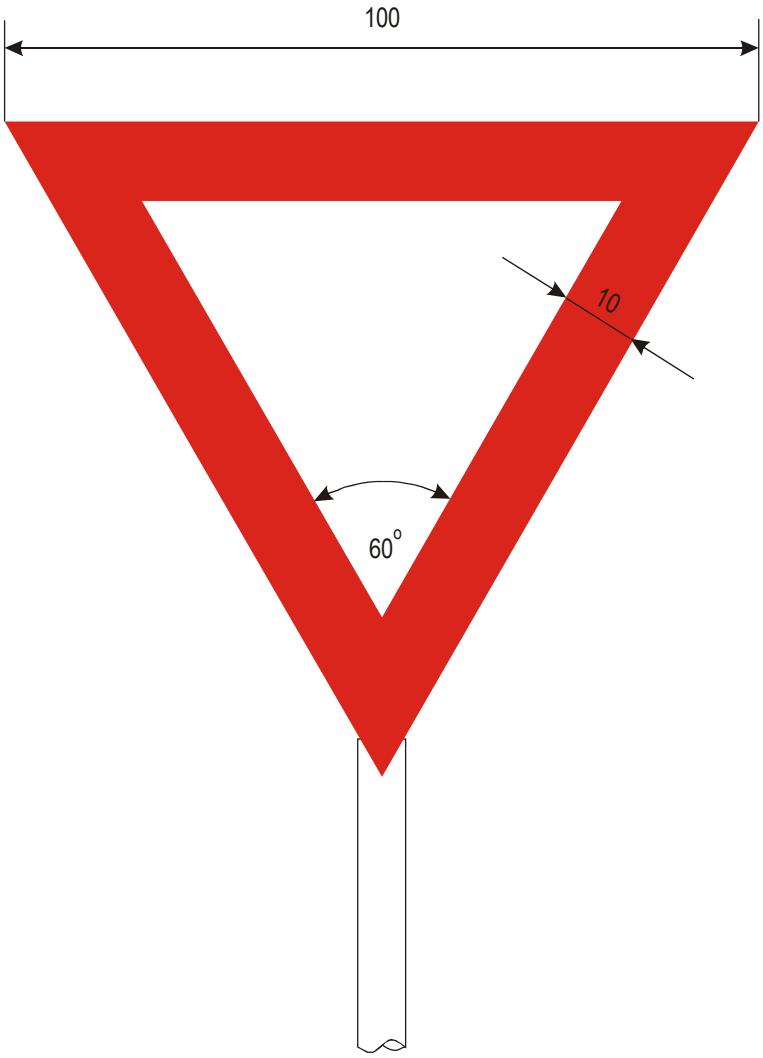

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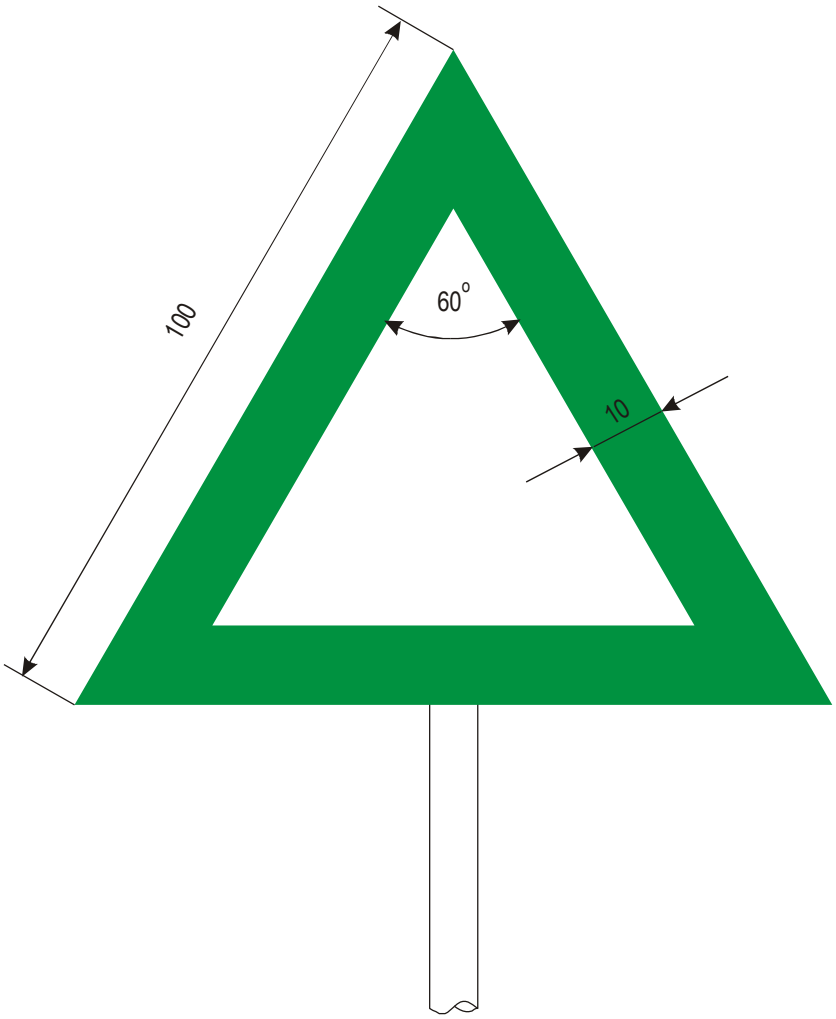
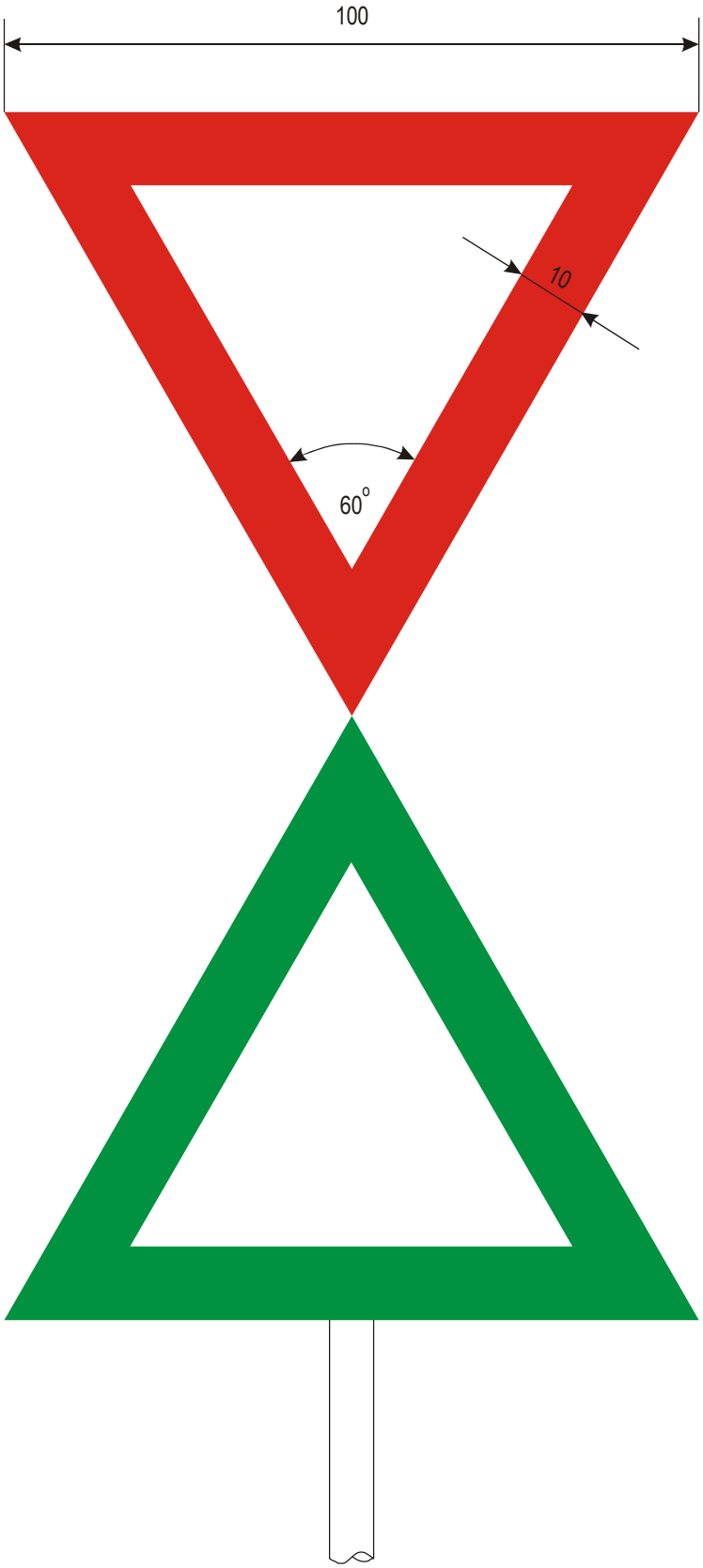
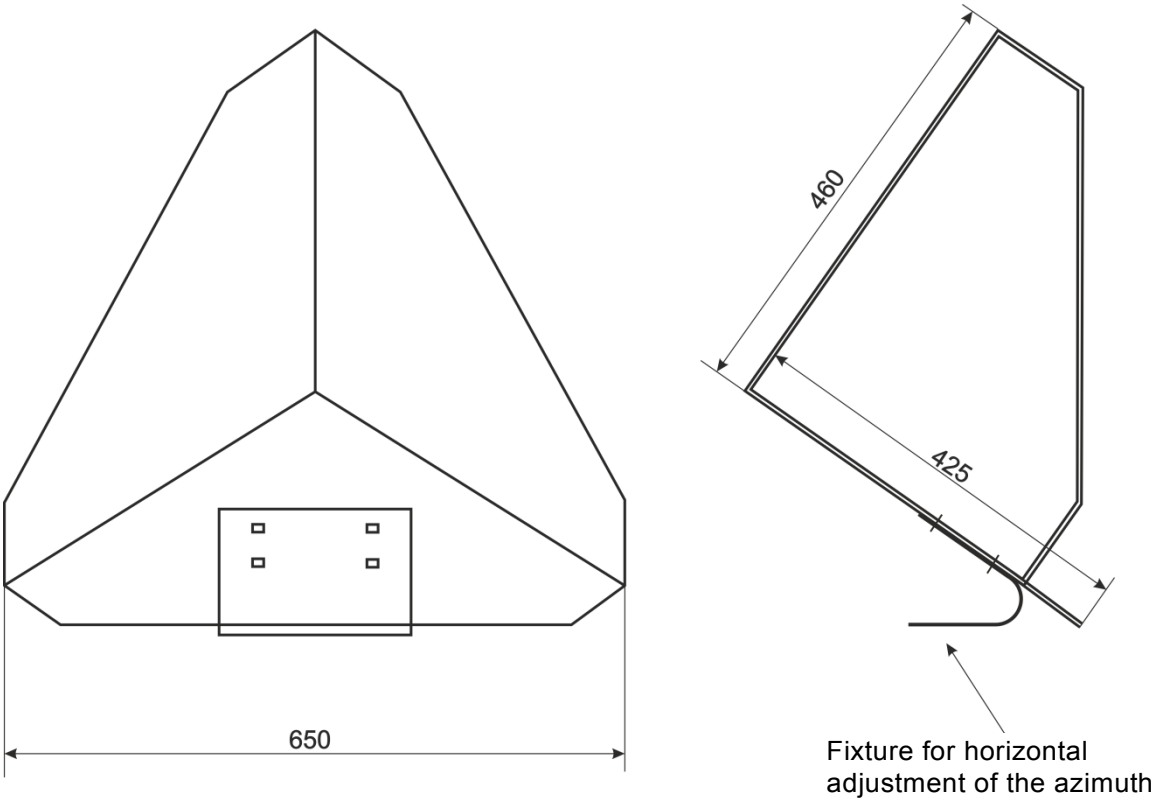


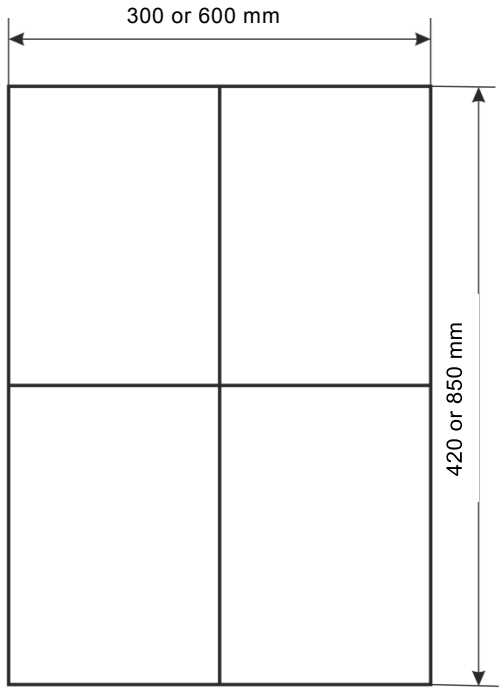
6.B

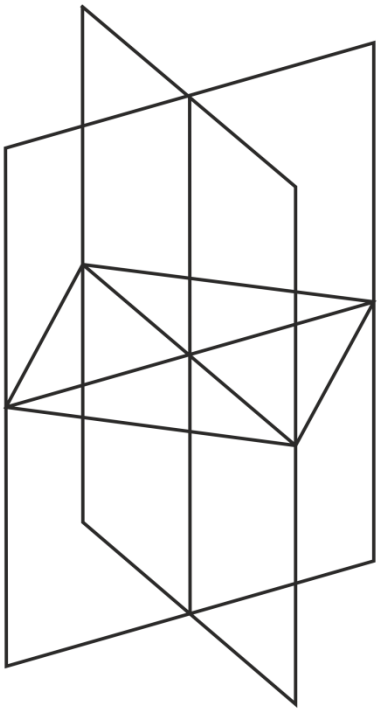


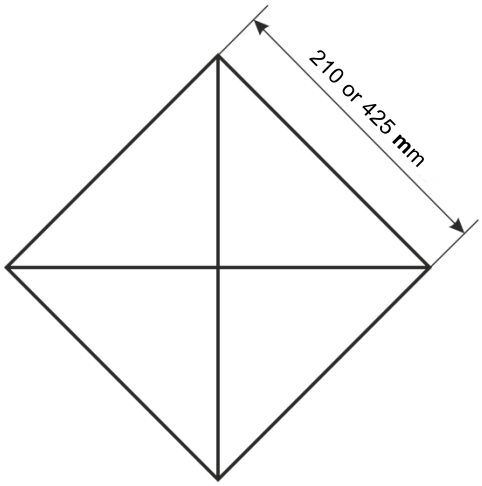
Radar reflectors on bridges



Radar reflectors on buoys and signs







Annex 2

Properties of lights

1. Categories of luminous intensity

Lanterns are classified according to their horizontally emitted photometric luminous intensity I_{ph}, in candelas.

By analogy with luminous intensity for lights on board vessels, three distinct categories have been established, according to power.

Table 1

Category	*By analogy with*	*Intensity of white light [cd]*	*Intensity of red/green/yellow light [cd]*
1	Ordinary light	2-9	0.8-3.5
2	Bright light	9-35	3.5-20
3	Strong light	35-100	20-50

2. Acceptable colours of lights

The colours of lights are described in a standard chromatic diagram pursuant to ISO 11664/ CIE S 014. The range of colours accepted in the standard chromatic diagram is determined according to the requirement of the International Commission on Illumination “Colours of Light Signals” standard, CIE S 004/E-2001, class A.

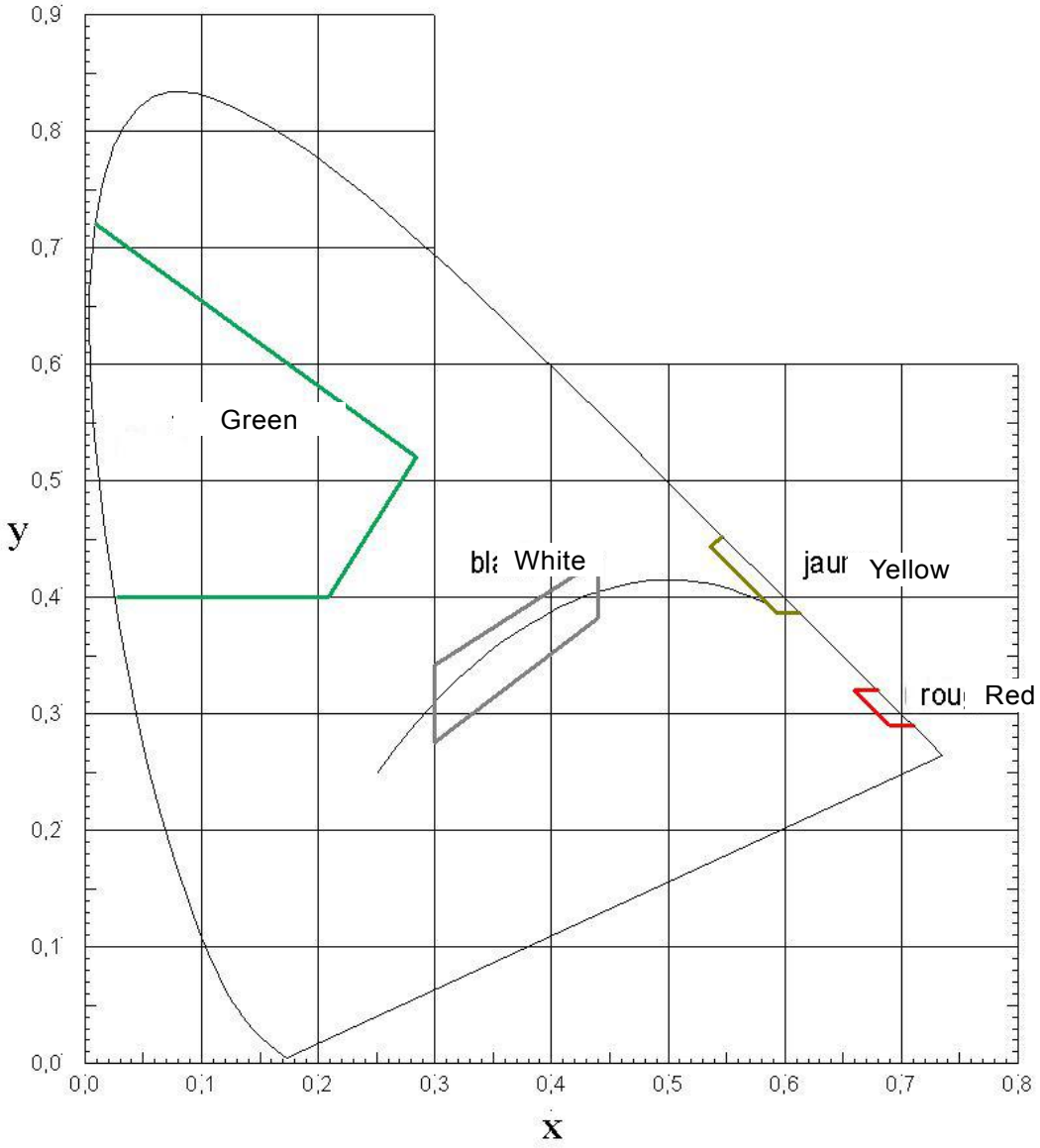
The chromatic coordinates for the acceptable ranges are as follows:

Table 2

		1	*2*	*3*	*4*
White	x	0.300	0.440	0.440	0.300
	y	0.342	0.432	0.382	0.276
Yellow	x	0.536	0.547	0.613	0.593
	y	0.444	0.452	0.387	0.387
Red	x	0.660	0.680	0.690	0.710
	y	0.320	0.320	0.290	0.290
Green	x	0.009	0.284	0.209	0.028
	y	0.720	0.520	0.400	0.400

The yellow/red/green colour ranges are limited in addition by the curve of the colour spectrum. The ranges of colours are set out in Figure 1.

Figure 1



3. Calculation of light range

The range of a signal light intended for the guidance of shipping is calculated according to the procedure contained in IALA[5] Recommendation E-200, Part 2 — Calculation, Definition and Notation of Luminous Range, which applies only to signal lights perceived as points by the observer.

Different criteria than those used to establish the range of on-board lights (navigation lights) have been developed for signals intended for the guidance of shipping, which use other values.

[5] IALA: International Association of Marine Aids to Navigation and Lighthouse Authorities, www.iala-aism.org.

The calculations are performed using the following formula:

$$D^2 \times E_t = I_{eff,B} \times T_M^{\frac{D}{1852m}},$$

Where D is the range of light;

$I_{eff,B}$ is the operational luminous intensity of the lantern;

T_M is the value for calculating visibility (describes the atmospheric transmissivity);

E_t is the established limit of luminosity.

The calculation must be done numerically; the formula cannot be solved according to D.

The parameters given are as follows:

$T_M = 0.6$;

$E_t = 2*10^{-7}$ lx for buoys with lights and simple bank lights with no background lighting;

$E_t = 10^{-6}$ lx to mark a cross-fairway axis with 2 or 3 lights with no background lighting;

$E_t = 2x10^{-6}$ lx for all lights with average background lighting (e.g. in a city);

$E_t = 2x10^{-5}$ lx for all lights with substantial background light (e.g. industrial facilities).

The operational luminous intensity $I_{eff,B}$ is a derivative of the photometric values I_{ph} according to the following calculations:

$$I_{eff,B} = b \times k \times I_{ph}.$$

Where b = 0.75 is the conventionally accepted loss factor owing to dirt and light source degradation.

The effective intensity of rhythmic lights is taken into account by the degree of transmission k, which is usually calculated according to IALA Recommendation E-200, Part 4 — Determination and Calculation of Effective Intensity.

For the light emitting diodes (LEDs) that are used in most cases and that permit very high frequency commutation, the calculations may be simplified to the following:

$$k = \frac{t}{0{,}2s + t}$$

Where t equals the shortest time of light for the rhythm of light used (e.g. 0.5 sec. for “Fkl. 1s” and 2 sec. for “Glt. 4s”).

The typical range with visibility $T_M = 0.6$

Table 3

Background lighting	*No*	*No*	*Average*	*Substantial*
Light limit Et [lx]	*$2x10^{-7}$*	*10^{-6} (marking of the axis)*	*$2x10^{-6}$*	*$2x10^{-5}$*
Luminous intensity Ieff,B [cd]		*Range [m]*		
1	1 760	890	650	220
2	2 300	1 200	890	300

Background lighting	*No*	*No*	*Average*	*Substantial*
Light limit Et [lx]	*$2x10^{-7}$*	*10^{-6} (marking of the axis)*	*$2x10^{-6}$*	*$2x10^{-5}$*
Luminous intensity Ieff,B [cd]		*Range [m]*		
5	3 210	1 760	1 320	470
10	4 050	2 300	1 760	650
20	5 010	2 970	2 300	890
50	6 470	4 050	3 210	1 320
100	7 720	5 010	4 050	1 760
200	9 060	6 100	5 010	2 300
500	11 000	9 060	6 470	3 210

Annex 3

Colours of reflected light for navigation signs

The colours of light reflected by navigation signs (day markings) must conform with publication No. 39-2 (TC-1.6) 1983 of the International Commission on Illumination (CIE) entitled “Recommendations for Surface Colours for Visual Signalling”.

The following is taken from the Recommendations:

- Ordinary colours of materials (standard colours), in this case: red, yellow, green, blue, white and black;
- Fluorescent colours of materials (luminescent in daylight), in this case: red, green.

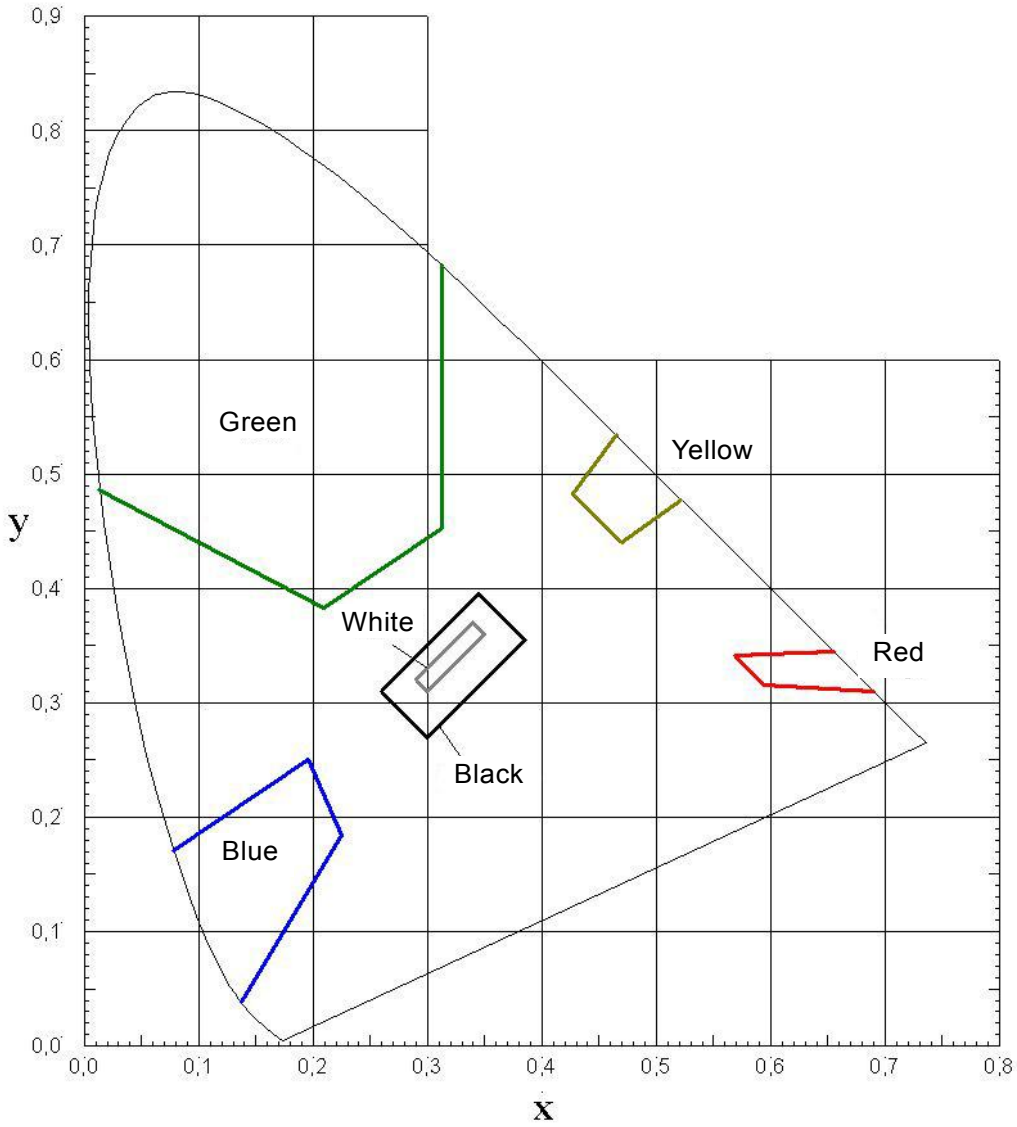
The acceptable colours are given in ranges and with a standard chromaticity diagram, specifying as well the requirements for intensity coefficients (luminance factors). The chromaticity coordinates for the ranges and intensity coefficients are shown in Table 1. For colours adjacent to the spectral colour curve, the curve represents their external limit.

Table 1

Colour of the reflected light	*Intensity coefficient*	*1*		*2*		*3*		*4*	
Standard colours		*x*	*y*	*x*	*y*	*x*	*y*	*x*	*y*
Red	> 0.07	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Yellow	> 0.45	0.522	0.477	0.470	0.440	0.427	0.483	0.465	0.534
Green	> 0.10	0.313	0.682	0.313	0.453	0.209	0.383	0.013	0.486
Blue	> 0.05	0.078	0.171	0.196	0.250	0.225	0.184	0.137	0.038
White	> 0.75	0.350	0.360	0.300	0.310	0.290	0.320	0.340	0.370
Black	< 0.03	0.385	0.355	0.300	0.270	0.260	0.310	0.345	0.395
Colours luminescent in daylight		*x*	*y*	*x*	*y*	*x*	*y*	*x*	*y*
Red	> 0.25	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Green	> 0.25	0.313	0.682	0.313	0.453	0.209	0.383	0.013	0.486

The figure below shows the admissible colour ranges on the standard chromaticity diagram. The ranges for ordinary colours and those that are luminescent in daylight (red/green) are identical; the colours differ only in their intensity coefficients.

Figure 1



A simplified description of the admissible colours can be presented using the RAL numbers from the internationally recognized RAL-Classic colour system.

RAL: RAL gemeinnützige GmbH, www.ral-farben.de

The colours below correspond with the CIE Recommendations and are preferred for use in transport technologies.

Table 2

Number	*Designation*		*Recommended use*
RAL 1023	Traffic yellow	Verkehrsgelb	Traffic signs, buoys
RAL 3020	Traffic red	Verkehrsrot	Traffic signs
RAL 3028	Pure red	Reinrot	Buoys, sufficiently visible traffic signs

Number	*Designation*		*Recommended use*
RAL 3024	Luminous red	Leuchtrot	Buoys, strongly visible traffic signs
RAL 5017	Traffic blue	Verkehrsblau	Traffic signs
RAL 6024	Traffic green	Verkehrsgrün	Traffic signs
RAL 6037	Pure green	Reingrün	Buoys, sufficiently visible traffic signs
RAL 6038	Luminous green	Leuchtgrün	Buoys, strongly visible traffic signs
RAL 9016	Traffic white	Verkehrsweiß	Traffic signs, buoys
RAL 9017	Traffic black	Verkehrsschwarz	Traffic signs, buoys

It is recommended that navigation sign surfaces, when they are not a part of the signs themselves, should be RAL 7042 traffic grey A or RAL 7043 traffic grey B.

It may be advisable to use adhesive light-reflective films on markers that are not equipped with lights. For the colours of light-reflective films, reference may be made to the relevant European standards for road transport.

Annex 4

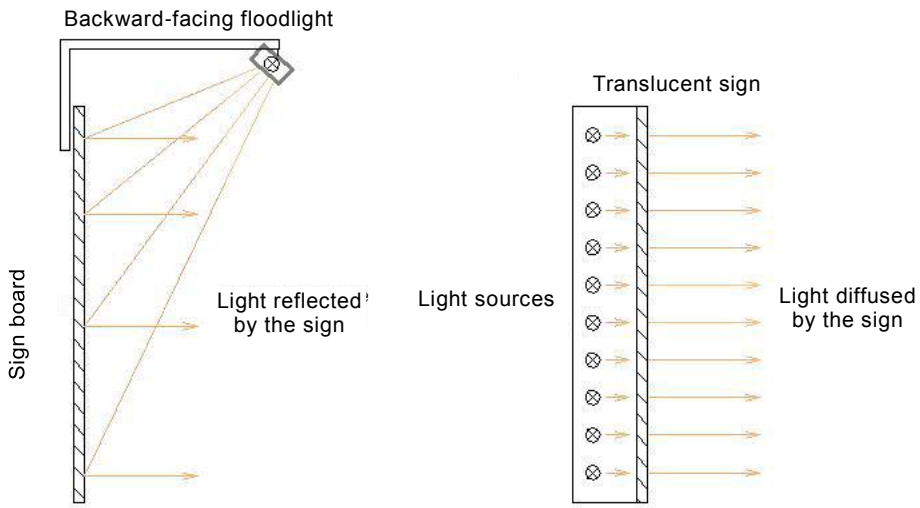
Lighting of traffic signs

It is recommended to arrange the lighting for signs on the basis of European standard EN 12899-1, entitled “Fixed, vertical road traffic signs”.

The lighting shall be turned on only at night. During daytime, the sign must be identifiable with natural lighting.

The lighting may be arranged either with an external, backward-facing floodlight located in front of the sign or with lighting from the inside of translucent panels (internally backlit signs).

Figure 1

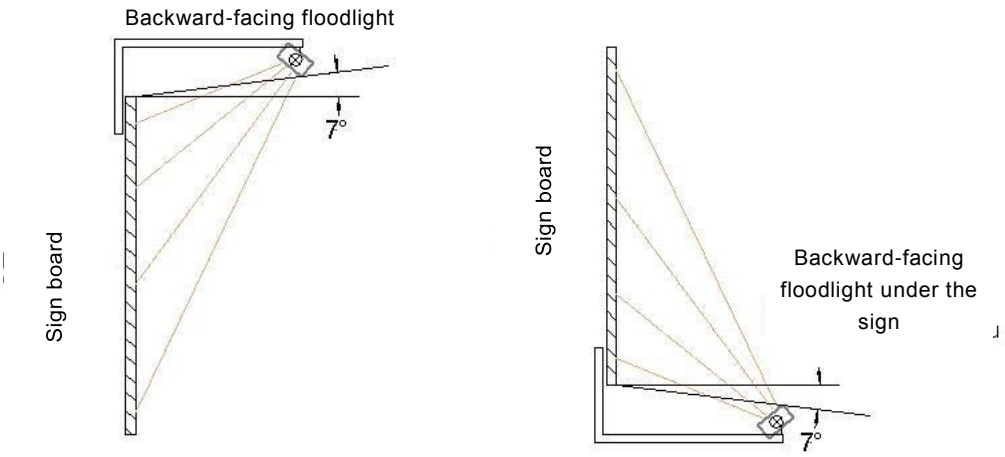


External backward-facing lighting

External backward-facing lighting from a floodlight located above the sign is generally arranged with floodlights affixed above or below the sign board. For tall signs it is advisable to affix two floodlights (above and below). For wide signs it is possible to affix several floodlights in a line.

To avoid undesirable dark spots and glare, the floodlights must be located in such a way that they do not block a view from an angle of 7 degrees from the horizontal, drawn from the sign’s top or bottom edge.

Figure 2



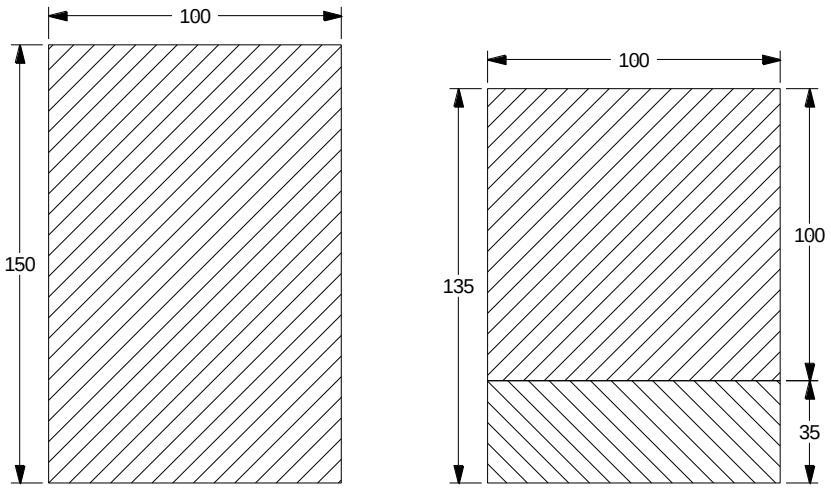
The type of lighting is always determined by the readability of the sign illuminated by the backward-facing light. Minimum dimensions are given in Annex 1 to these Instructions.

With some boards, the illuminated surface is identical to the board itself. If several boards conveying a single message are installed, for instance with additional text plates, the lighting requirements refer to the overall surface of the combined boards.

The drawing on the left shows the backward-illuminated surface of a sign board.

The drawing on the right shows the backward-illuminated surface of a sign board with an additional plate.

Figure 3



As for the backward-illuminated surface, the following lighting parameters should be observed:

In areas with insignificant background light levels (for example, outside of city limits), the luminosity measured on-site should range from 40 lx to 100 lx, corresponding with Class E1 under EN 12899.

In areas with increased background light levels (for example, within city limits), the luminosity measured on-site should range from 100 lx to 400 lx, corresponding with Class E2 under EN 12899.

The uniformity of lighting is established by the ratio between the minimum luminosity (E_{min}) and the maximum luminosity (E_{max}) on the back-illuminated surface. In all cases the ratio must be greater than or equal to 1:10 (E_{min}:$E_{max} \geq$ 1:10), corresponding with Class UE1 under EN 12899.

For the lighting, a white lamp with a colour temperature between 3500 K and 4500 K is used. Care must be taken to ensure that the sign colours are reproduced when the backward-facing light is white.

Internally backlit signs

If internally backlit signs are used, they must during daytime meet the requirements for unlit signs, and similarly at night must meet those of European standard EN 12899.

It is therefore recommended to use intensity class L1 for signs in areas with insignificant background light and intensity class L2 for those with increased background light levels.

As for the uniformity of the lighting, the aim should be to reach class U1 (1:10).

Annex 5

Examples for variable-message traffic signs

For road traffic, there is a European standard for variable-message traffic signs, EN 12966-1, entitled “Vertical road signs — Part 1: Variable message signs”, the content of which is partially applicable to inland navigation. It is recommended to comply with this standard when producing variable-message traffic signs.

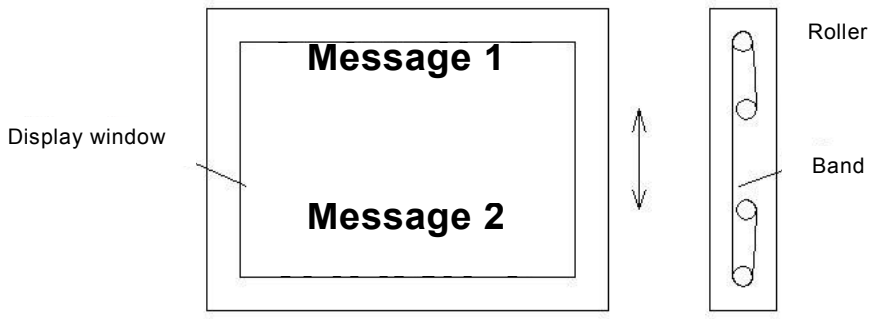
1. Mechanical boards

1 (a) Scrolling sign boards

Boards with a scrolled band of sign images are useful as variable message traffic signs, in particular for displaying the signs in Annex 7 to DFND.

The sign images are placed on a band that is scrolled vertically on rollers. The rollers place the currently valid image in the window for display.

Figure 1



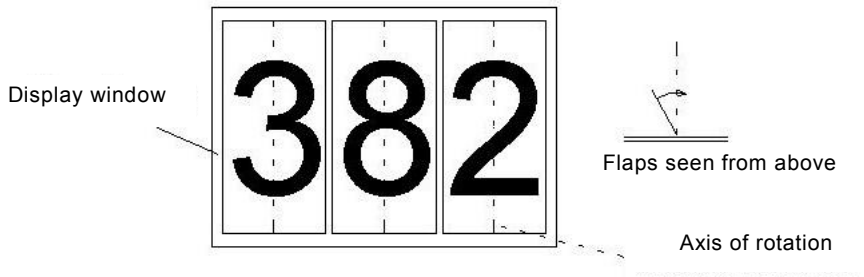
The advantage of scrolling sign boards is that they make it possible to display a large number of signs.

1 (b) Split-flap displays

Split-flap displays are more suited for displaying numbers. Generally, the image is divided into a number of zones so that the rotating surface is reduced.

A full image of a sign from Annex 7 to DFND would have to be divided into several zones on a split-flap display, with the image becoming fragmented. These boards are therefore not suitable to display such sign images.

Figure 2

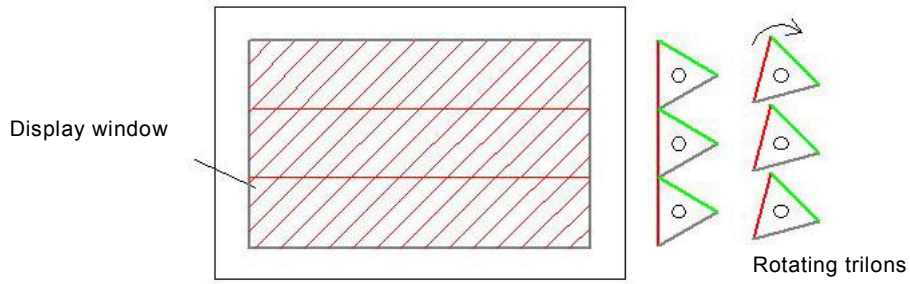


For numerical displays (water levels, cross currents), each digit is displayed using a pile of split flaps capable of representing the numbers from 0 to 9.

1 (c) Trilons

Trilon boards are used preferably to display two different signs from Annex 7 to DNFD. This technique is limited to displaying three distinct sign images. Generally, the third position is reserved as blank, with a gray surface.

Figure 3



In comparison with boards using scrolling bands, the advantage of trilons is that they are mechanically more robust. At the same time, it is not necessary to produce sign images on a flexible surface, which makes it possible to use paints and films of proven value for use on navigation signs.

1 (d) Other mechanical boards

There are many mechanical systems for information boards (for example, including flip-disk boards), with many designed for use in indoor spaces (such as transport terminals or stations). For navigation signs, which generally have to bear the brunt of weather conditions, the service life of such systems is often negligible; they often require servicing.

2. Electronic boards

Purely electronic systems for information boards have the basic advantage of incorporating absolutely no moving parts. The ones that are best known are boards using light-emitting diodes (LEDs), liquid crystals or optical fibres.

Such messages must be displayed as white or yellow digits or letters on a black background.

During manufacture, the characters have to be converted into groups of constituent dots to ensure that they can be read.

While mechanical boards are visible with natural light during daylight hours, electronic boards have to emit light both day and night.

At the same time, a contrasting frame is required, the aim being to reduce the so-called phantom effects caused by sunlight. Reflection angles must be sufficiently large to reliably eliminate reflections on the fairway segments in question.

As a direct consequence, electronic boards consume significantly more energy than mechanical ones.

At the same time, in daylight, the boards must be sufficiently luminous so that their messages can be seen even in clear and sunny weather. At night, they must be darkened so as to avoid unwanted brightness or dazzle.

Adjustments are made by measuring the background luminous intensity and adapting the intensity of the board accordingly. It is recommended to do this in accordance with the requirements of standard EN 12966-1, with the adjustment coefficient (the board's maximum-to-minimum luminosity ratio) exceeding 100:1.

The boards' reflection angles should also be observed. Possible reflection angles appear in standard EN 12966-1. The luminance classes described therein are intended for road traffic and would presuppose that the boards are installed at least as high as the maximum height of a bridge allowing for navigation.

For horizontally illuminated sectors there are classes with ranges up to +/- 30° (60°). For boards (for example indicating water levels) whose faces are parallel to the bank of a waterway, the maximum class in standard EN 12966-1 might be insufficient in certain circumstances. Technically, it is possible to display sectors ranging up to +/- 60° (120°) at an acceptable cost.

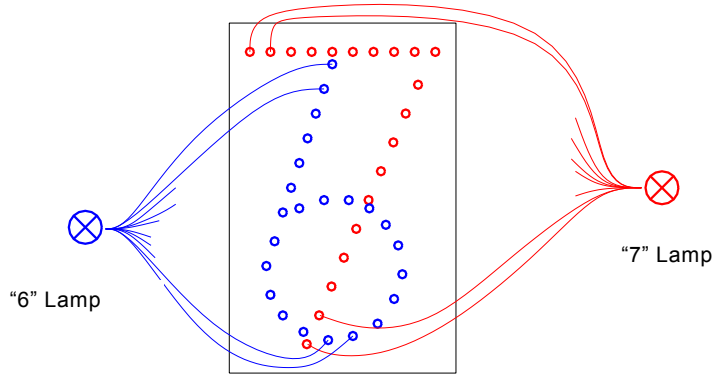
2 (a) Optical waveguide (optical fibre) boards

Optical fibre boards have been used for many years on variable message road traffic signs (for example, to display temporary speed limits). The sign's image is divided into distinct points of light, with each point backlit by an optical fibre.

When a digit is displayed, the optical fibres of the digit in question are grouped and backlit with a lamp. For each digit there is thus a separate lamp, and each point of light can be used for just one digit. The points thus cannot be individually controlled. Each image must in turn have a source lamp.

Figure 4

Depiction of light points corresponding with lamps for two digits (for clarity, only some of the optical fibres are shown).



In recent years, optical fibre boards have to a great extent been replaced by light-emitting diode (LED) matrix boards.

2 (b) Light-emitting diode (LED) matrix boards

In the case of a light-emitting diode (LED) matrix, each separate point of the image is displayed by a diode that can be independently turned on and off. In principle, such boards can be freely programmed (using a complete matrix), thus making it possible to display any message.

Figure 5

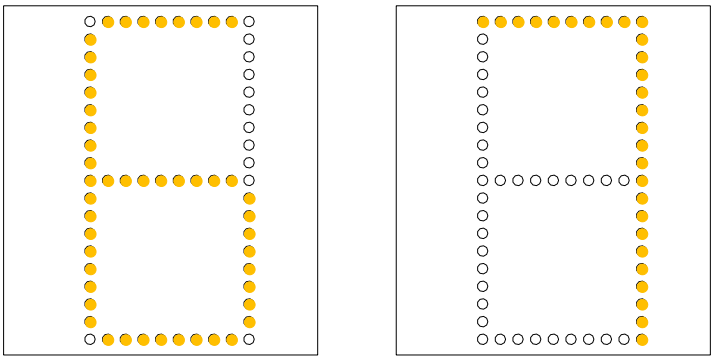
Individually controlled light emitting diodes displaying digits

Often, though, only seven segments required to display digits are connected.

As fewer diodes are used, the electronic control is simplified, which results in savings. To reduce costs, it is possible to pre-programme groups of LEDs to display only the messages that are required.

Figure 6

Board composed of seven segments with separate light emitting diodes



2 (c) Liquid crystal displays (LCDs)

Boards using liquid crystal displays (LCDs) are composed of a regularly illuminated surface placed behind a film of liquid crystals, which blocks areas of the image, thus creating the desired figure. For large boards, monochrome images are preferred, although colour images are possible as well. Diodes have recently been employed to backlight the surface, while fluorescent lamps were previously used.

The advantage of this kind of board is that it produces a very sharp, detailed image, with such high luminosity and contrast that the boards can be used in daylight.

There is a technical disadvantage, though, as the optical characteristics of the liquid crystal film are such that only a small part (less than 25 per cent) of the generated light is displayed. For the same luminosity, boards of this kind require significantly more power than those using LED matrices.

What is more, because liquid crystal displays are extremely sensitive to temperature changes and humidity, they must be protected, which involves high costs.