KOLEJOWE ZAKŁADY NAWIERZCHNIOWE
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Manufacturing catalogue: tramway tracks

4th edition – July 2013

Contents

1 Introduction

KZN „Bieżanów” Sp. z o.o. is one of the largest and best recognised manufacturers of railway and tramway turnouts in Poland and in Europe. As a result of 65 years of experience, continually upgraded machine fleet, state-of-the-art processes applied and above all its skilled staff, KZN "Bieżanów" has become a leader in the fields of manufacture, supplies, assembly and installation of turnouts and complete rail systems in permanent ways.

Considering the growing needs of the demanding railway and tramway market, KZN "Bieżanów" systematically develops its offer. The growth of our company, diversification of its products and services enables us to continually increase our market share. Our success is based not only on manufacturing activities but also on comprehensive customer service, including warranty and post-warranty maintenance service, provided in accordance with the implemented **IRIS standard**. We guarantee the full scope of service, starting from design to product supplies, assembly and construction of permanent ways for urban and railway transport. We are also specialists in the manufacture of special permanent ways, such as those used in mountain railways or in the mining industry.

The scope of our manufacturing services includes steel structures and machining of steel components, according to documentation developed by our internal design office or submitted by our customers. To meet the market expectations, we adapt our offer to more and more demanding requirements, seeking innovative technology solutions and opportunities to apply advanced raw materials and intermediate products.

Our offer includes:

- Designing new engineering solutions for permanent ways
- Manufacturing services
- Supplies of turnouts with selected suitable turnout sleepers
- Disassembling old permanent ways and building new ones in all technologies
- Supplies of materials for permanent ways

In 2009, KZN "Bieżanów" was the first turnout manufacturer to supplement its ISO 9001:2008 Quality Management System with a new railway standard known as IRIS (International Railway Industry Standard). The certificate issued by Bureau Veritas Poland confirms the high quality of products manufactured and services provided by our company and makes sure that we accept full responsibility for our product throughout its life cycle.

2 The catalogue

2.1 Purpose of this document

The described offer includes our proposals of engineering solutions for turnout parts and track components for tramways. It is addressed to designers, investors financing tramways and their users.

2.2 Turnouts and track crossings

2.2.1 Structural components of turnouts and track crossings

The main structural components of turnouts and track crossings are shown in **Figures 1 and 2.**

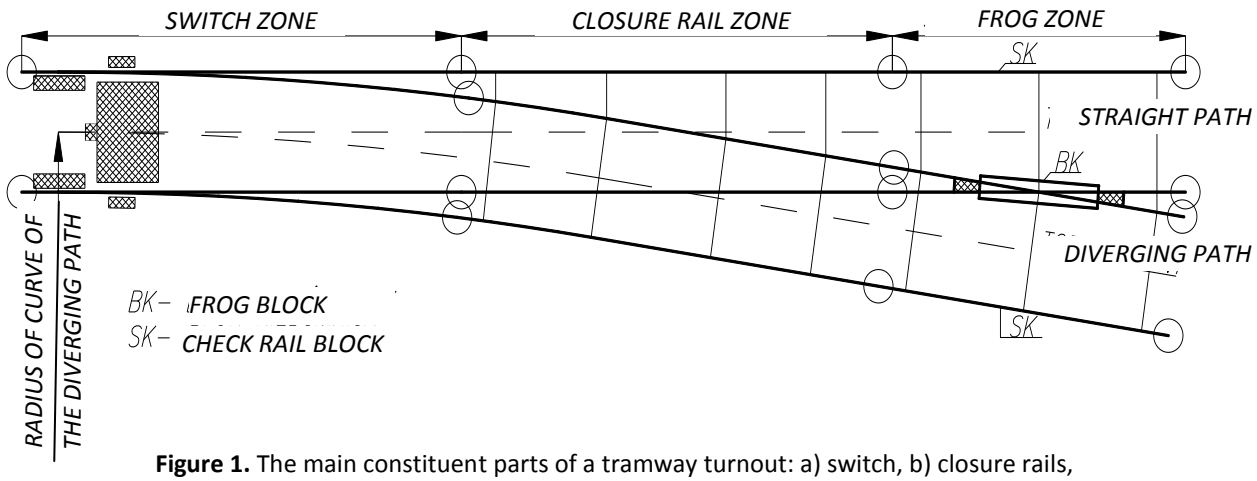


Figure 1. The main constituent parts of a tramway turnout: a) switch, b) closure rails,

c) frog(s)

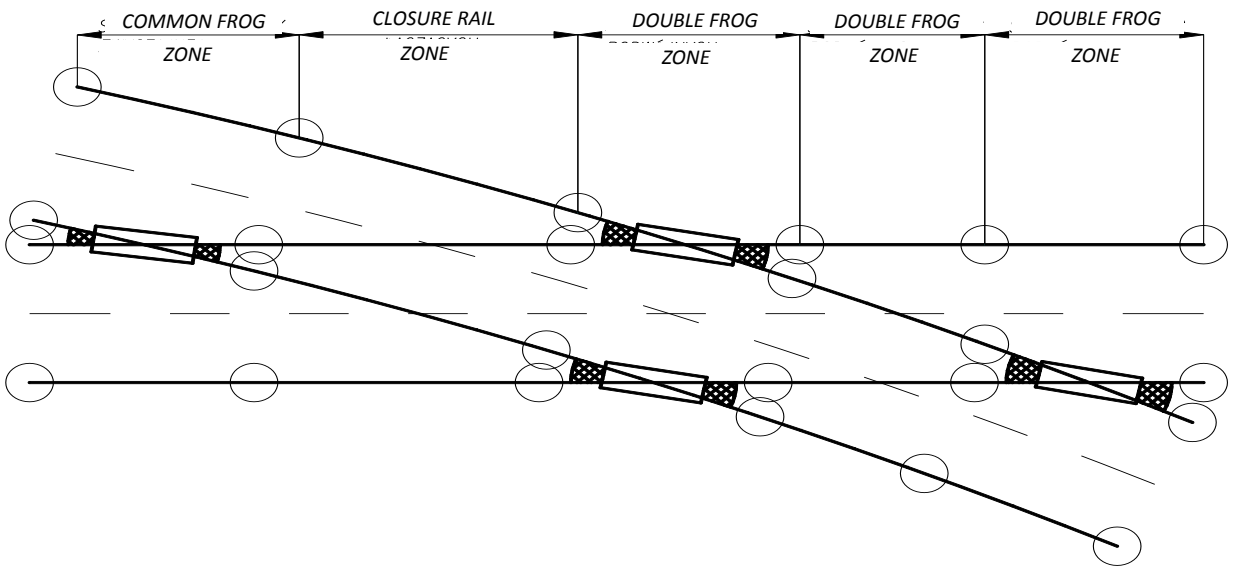


Figure 2. The main constituent parts of a track crossing: a) single (common) frogs

b) double frogs c) closure rails

2.2.2 Geometric layouts of tramway tracks (track-work formations)

Depending on the number of tracks and the design of their junction, the following geometric layouts of tramway tracks may be distinguished:

- One-track single tramway turnout, including one switch and one straight frog (**Figure 3a**),

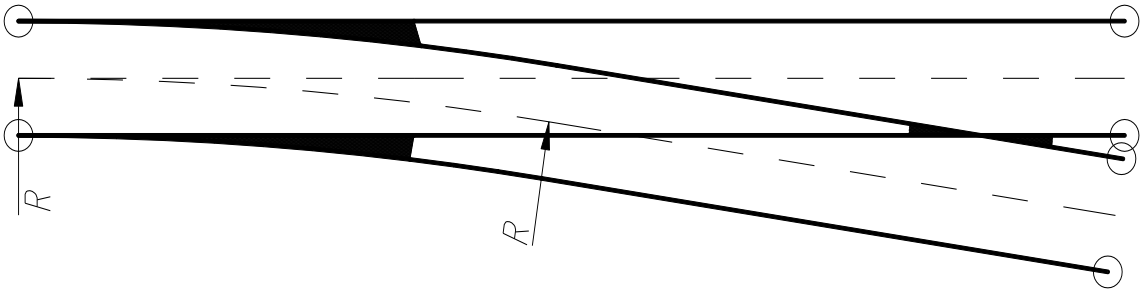


Figure 3a. One-track right-hand single tramway turnout with a straight frog

- One-track single tramway turnout, including one switch and one curved frog (**Figure 3b**),

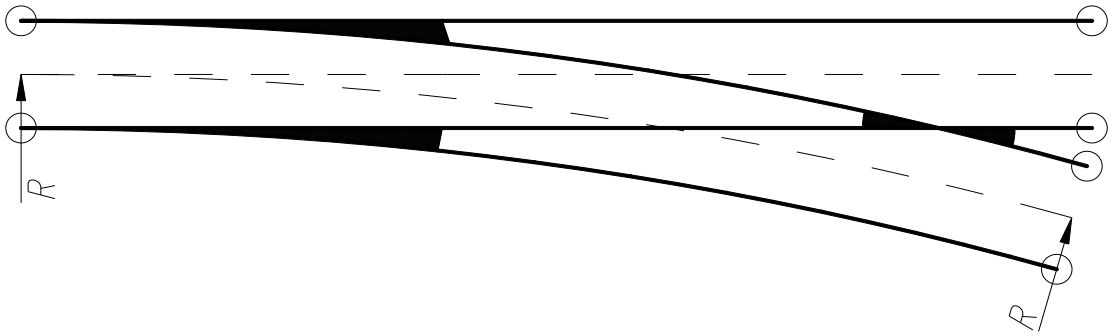


Figure 3b. One-track right-hand single tramway turnout with a curved frog

- One-track one-way double tramway turnout, including two switches and three frogs (**Figure 3c**),

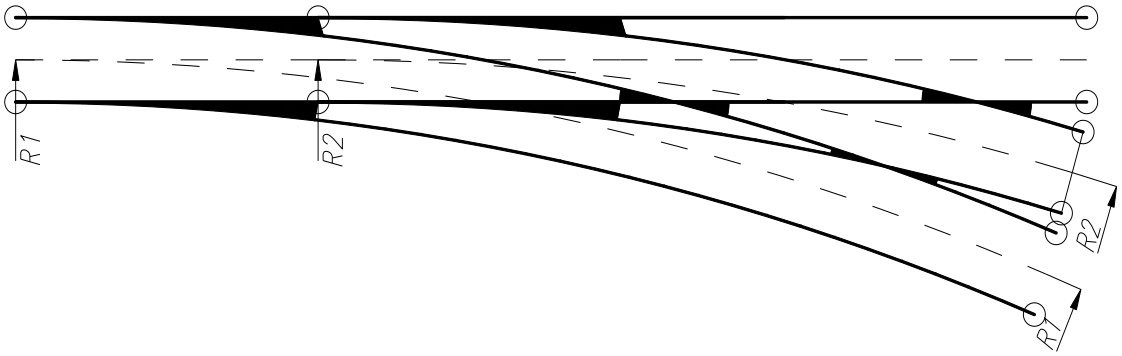


Figure 3c. One-track right-hand double tramway turnout

- One-track three-way double tramway turnout, including two switches and three frogs (**Figure 3d**),

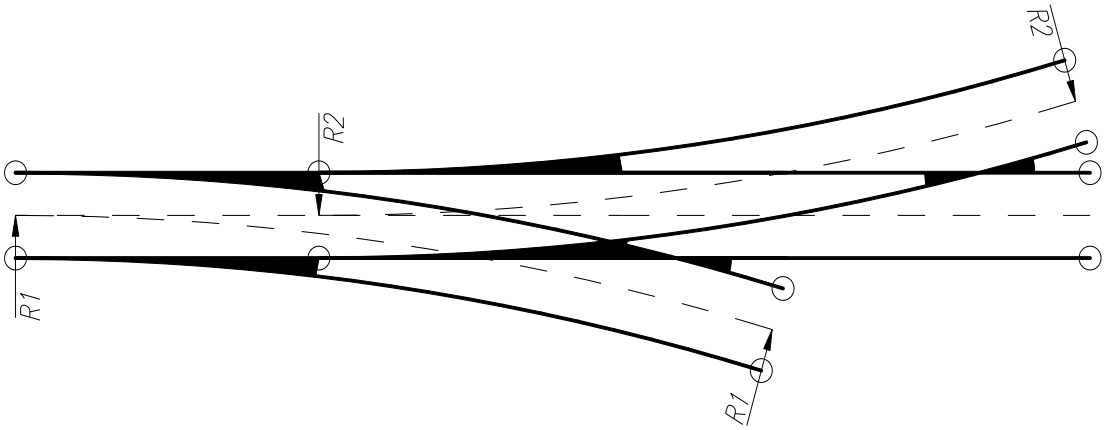


Figure 3d. One-track three-way double tramway semi-turnout

- Double-track single tramway semi-turnout, including one switch and five frogs (**Figure 3e**),

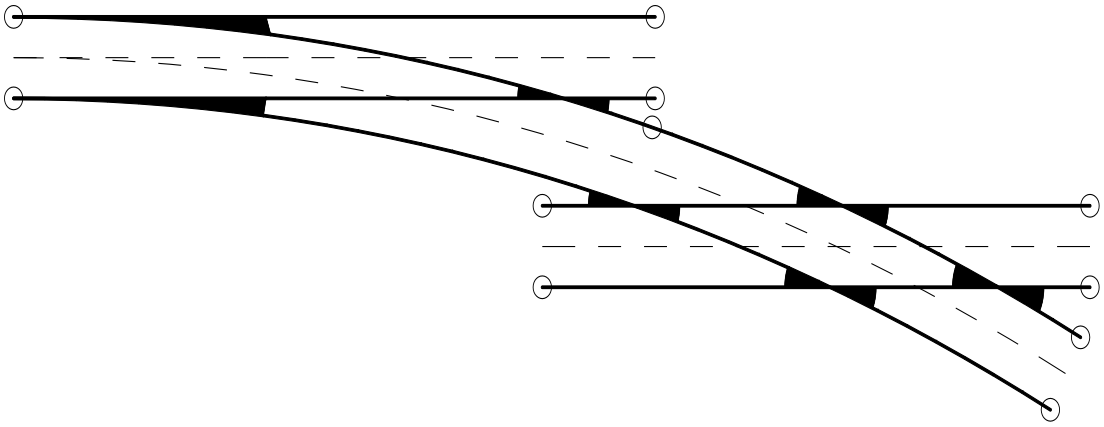


Figure 3e. Double-track right-hand single tramway semi-turnout

- Double-track single tramway full turnout, including two switches and six frogs (**Figure 3f**),

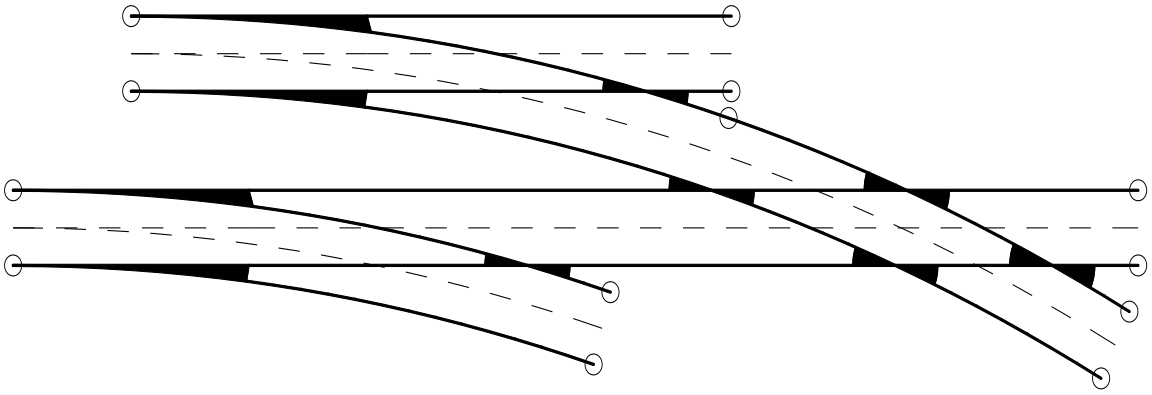


Figure 3f. Double-track right-hand single tramway full turnout

- Double-track double tramway turnout, including four switches and eighteen frogs (**Figure 3g**),

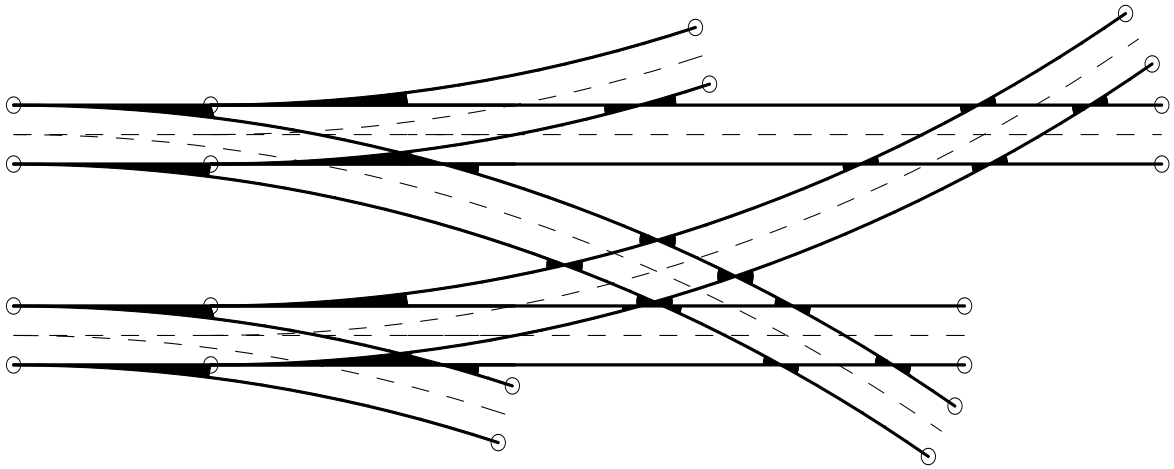


Figure 3g. Double-track double tramway turnout

- One-track single diamond crossing, including four frogs (**Figure 3h**),

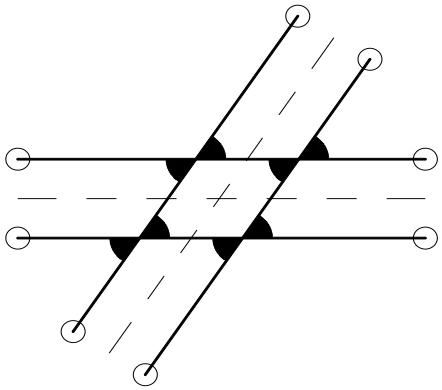


Figure 3h. One-track single diamond crossing.

- Double-track single diamond crossing, including eight frogs (Figure 3i),

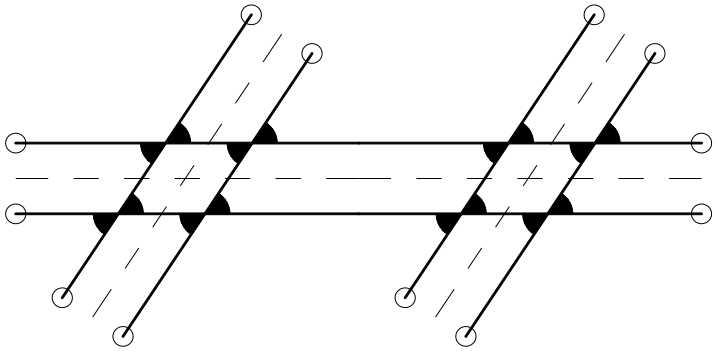


Figure 3i. Double-track single diamond crossing.

- Double-track double diamond crossing, including sixteen frogs (Figure 3j),

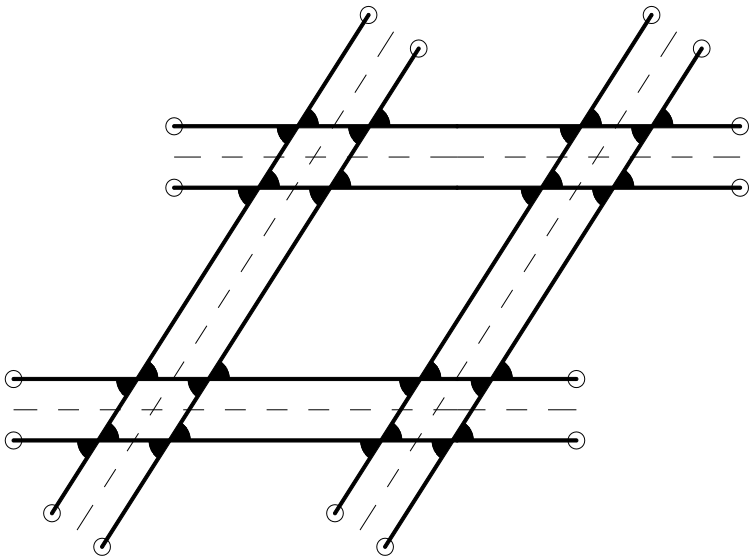
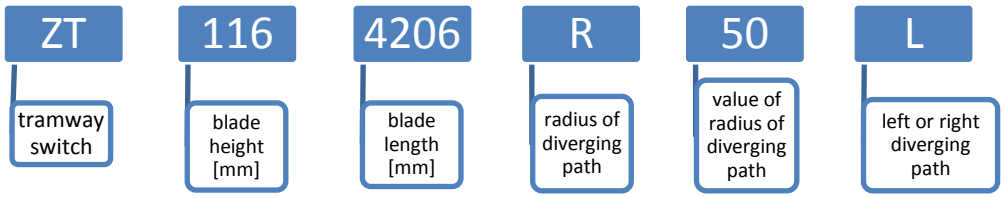


Figure 3j. Double-track double diamond crossing.

2.3 Tramway switches



2.3.1 Explanation of product codes

2.3.2 Technical and operating parameters:

The value of transport intensity is expressed in cars/h and Tg gross/year (millions of tonnes gross/year)

- heavy traffic 45-60 cars/h (1800 t/h) and q≥8Tg/year
- medium traffic 20-45 cars/h (600-1000 t/h) and q≥5Tg/year
- light traffic – up to 20 cars per hour (up to 600t/h) and q<5 Tg/year

Steel grades:

Steel grade	HBW (Brinnel Scale)
R200	200-240
R220G1	220-260
R260 grade	260-300
R260GHT	260-300
R290GHT	290-330
R340GHT	340-390

Table 1 Steel grades according to PN EN 14811:2006 for groove profiles

Steel grade	HBW (Brinnel Scale)
R200	200-240
R220	220-260
R260 grade	260-300
R260Mn	260-300
R260Cr	260-300
R320Cr	320-360
R350HT	350-390
R350LHT	350-390

Table 2 Steel grades according to PN EN 13674-2:2006 for railway profiles

2.3.3 Technical characteristics of the switches

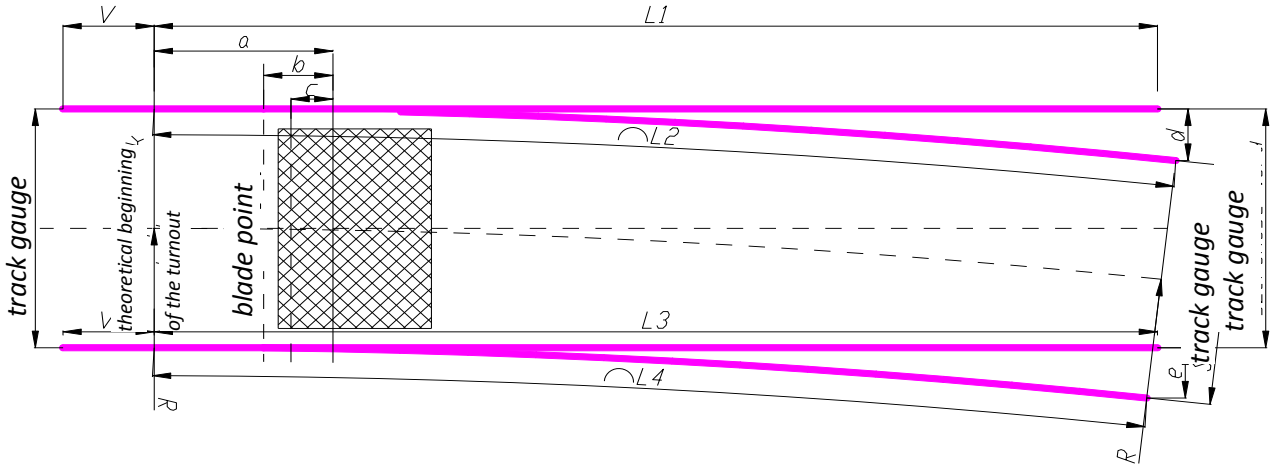


Figure 4. A schematic plan of a tramway switch

		R=50m				R=100m	R=∞	
Switch type		ZT-60-3000	ZT-75-3800	ZT-116-3200	ZT-116-4206	ZT-116-4900	ZT-75-4050	ZT-116-5450
Switch blade	Height	60 mm	75 mm	116 mm	116 mm	116 mm	75 mm	116 mm
	Steel grade	R260 grade	R260 grade	R260/R350HT	R260/R350HT	R260/R350HT	R260 grade	R260/R350HT
V		500	500	700	700	200	500	500
a		980	980	1000	1000	1200	980	1100
b		380	380	350	350	400	380	350
c		230	230	230	230	230	230	230
d*		310	310	278	278	243	190	114
e*		301	301	286	286	247	190	114
L1		5500	5500	5300	5300	7000	6660	8500
L2		5612	5612	5310	5310	7000	6666	8500
L3		5500	5500	5300	5300	7000	6660	8500
L4		5453	5453	5310	5310	7000	6666	8500

*a dimension measured at the end of the rails

Switch rail type and steel grade – 60R2 R260 grade; R290GHT or R340GHT

Track gauge –1435 mm or 1000 mm

Table 3 Statement of characteristic parameters of tramway switches

2.3.4 Main switch components

The main components of a switch include: blades, stock rails and check rails whose shapes and relative locations, depending on engineering solutions, are shown in **Figures 5a and 5b**.

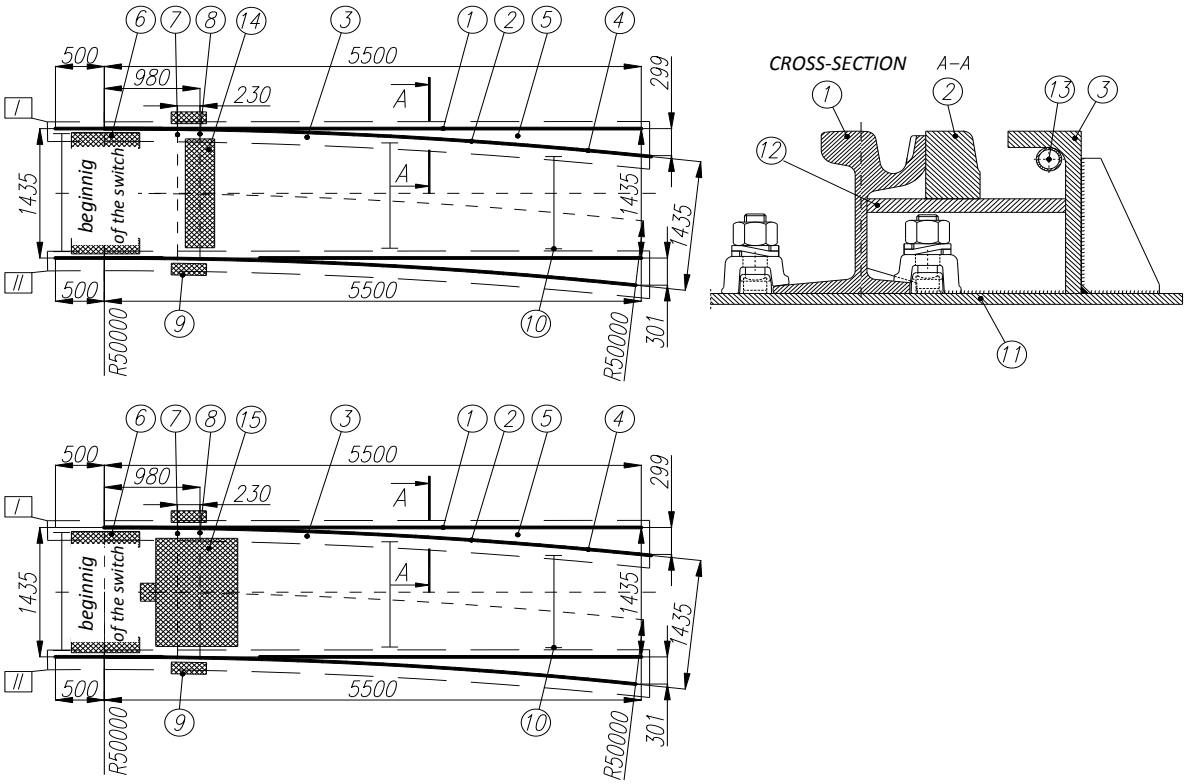


Figure 5a. Structural components of a right hand switch with low switch blades: I- the left half of the switch, II- the right half of the switch, 1- stock rail, 2- low blade, 3- check rail of the switch, 4- blade closure rail, 5- blade holder, 6- heating cubicle, 7- blade position controller, 8- connecting (switching) rod, 9- rod connection box, 10- stretcher bar with shims, 11- switch base plate, 12- slide plate, 13- heater with a protective tube, 14- lever box, 15- switch machine box.

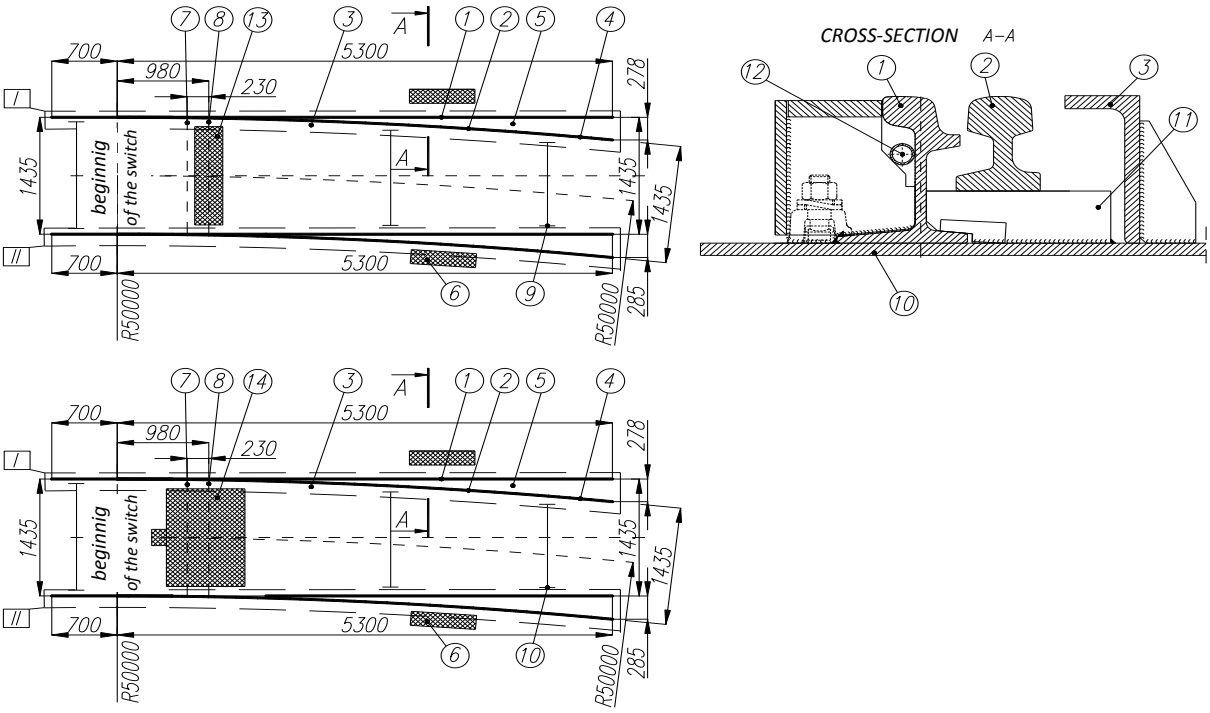
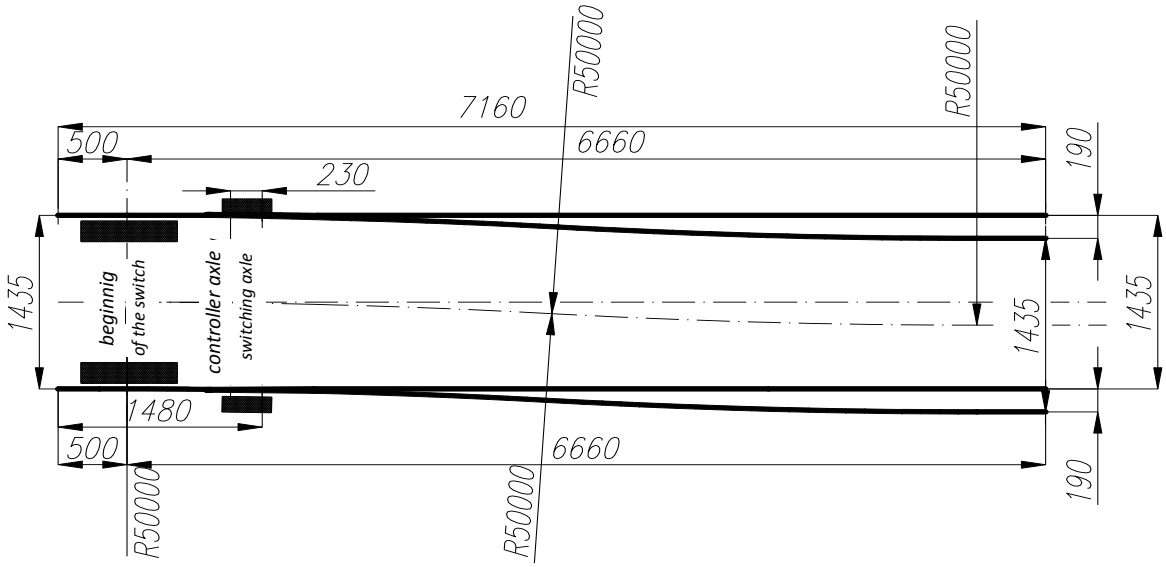


Figure 5b. Structural components of a right switch with high switch blades: I- the left half of the switch, II- the right half of the switch, 1- stock rail, 2- high blade, 3- check rail of the switch, 4- blade closure rail, 5- blade holder, 6- heating cubicle, 7- blade position controller, 8- connecting (switching) rod, 9- stretcher bar with shims, 10- switch base plate, 11- slide chair, 12- heater with a protective tube, 13- lever box, 14- switch machine box.

2.3.5 Other types of switches

This catalogue also describes switches with extended blade zones, to be installed in crossovers that require traffic separation before the junction. This type of switch is typically installed outside the vehicular or pedestrian traffic area. Examples of switches with extended blade zones are shown in **Figures 6a and 6b**.



a)

Figure 6a. The principle of geometric layout of a switch with an extended blade zone – a right-hand switch with low blades

b)

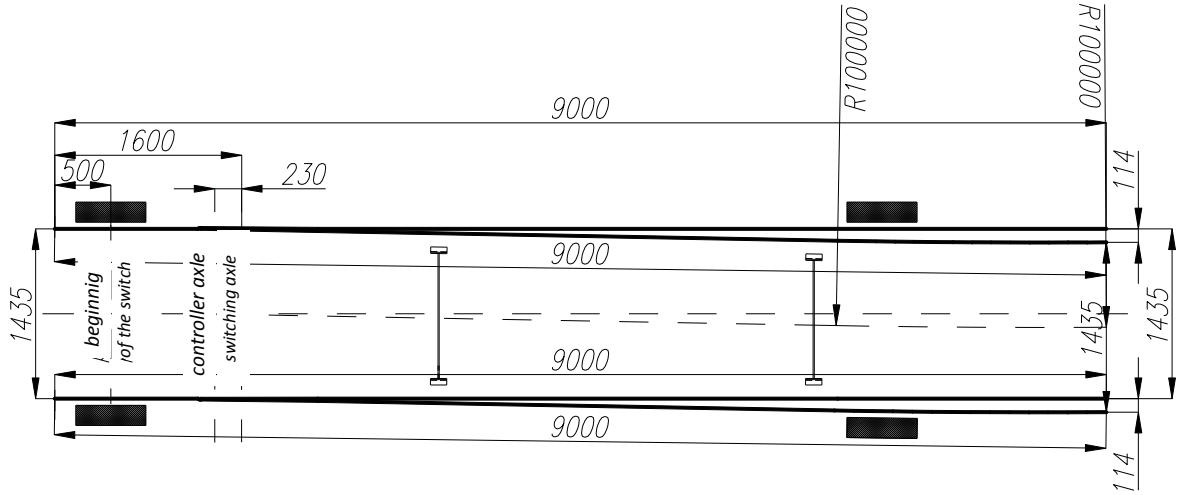


Figure 6b. The principle of geometric layout of a switch with an extended blade zone – a right-hand switch with high blades

2.3.6 Tramway switch of the ZT-60-3000 R=50m type

2.3.6.1 Technical data

- According to Table 3
- Designed for light traffic – up to 20 cars per hour (up to 600t/h) and q<5 Tg/year

2.3.6.2 Product description

The blades are made from the R260 steel grade with a surface hardened to 320 HB (±30) in order to extend operational durability of the head.

The blades are supported by a continuous steel plate and in their initial parts mounted on two chairs to facilitate the operation of the machine and locks.

Each half of the switch is equipped with one box containing heating devices, designed as a casing for electrical connections with heaters and with an inspection box giving access to the hooks at the ends of the connecting rod.

Each half of the switch is installed on a steel plate 12 mm or 15 mm thick, suitable for fastening on wooden sleepers or a concrete slab.

2.3.6.3 Product manufacture formula

Our offer includes both complete switches and blades to replace worn components in turnouts manufactured before 2005.

2.3.7 Tramway switch of the ZT-75-3800 R-50m type

2.3.7.1 Technical data

- According to Table 3
- Designed for medium traffic 20-45 cars/h (600-1000 t/h) and 8Tg/year>Q≥5Tg/year

2.3.7.2 Product description

The blades are made from the R260 steel grade and installed in the turnout using a method facilitating their replacement. Due to a small surface of their profiles (cross sections), the blades are supported at their entire length by a steel plate, and their initial sections are supported by two chairs that facilitate the operation of machines commonly used in Poland and abroad. The heads of the blades are surface-hardened up to 320HB (±30) to increase their useful life.

The switches are equipped with two types of boxes: heating and inspection boxes.

The heating boxes are designed as casings for electrical connections with heaters and also facilitate the replacement of a damaged heater with a new one.

The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion, laid under the check rail supporting plate, nearby the blades.

The inspection boxes are designed to facilitate access to the end hooks of the connecting rods attached to the blades.

Each half of the switch is installed on a steel plate 12 mm or 15 mm thick, suitable for fastening on wooden sleepers or a concrete slab.

2.3.7.3 Product manufacture formula

Our offer includes both complete turnouts and blades to replace worn components in turnouts.

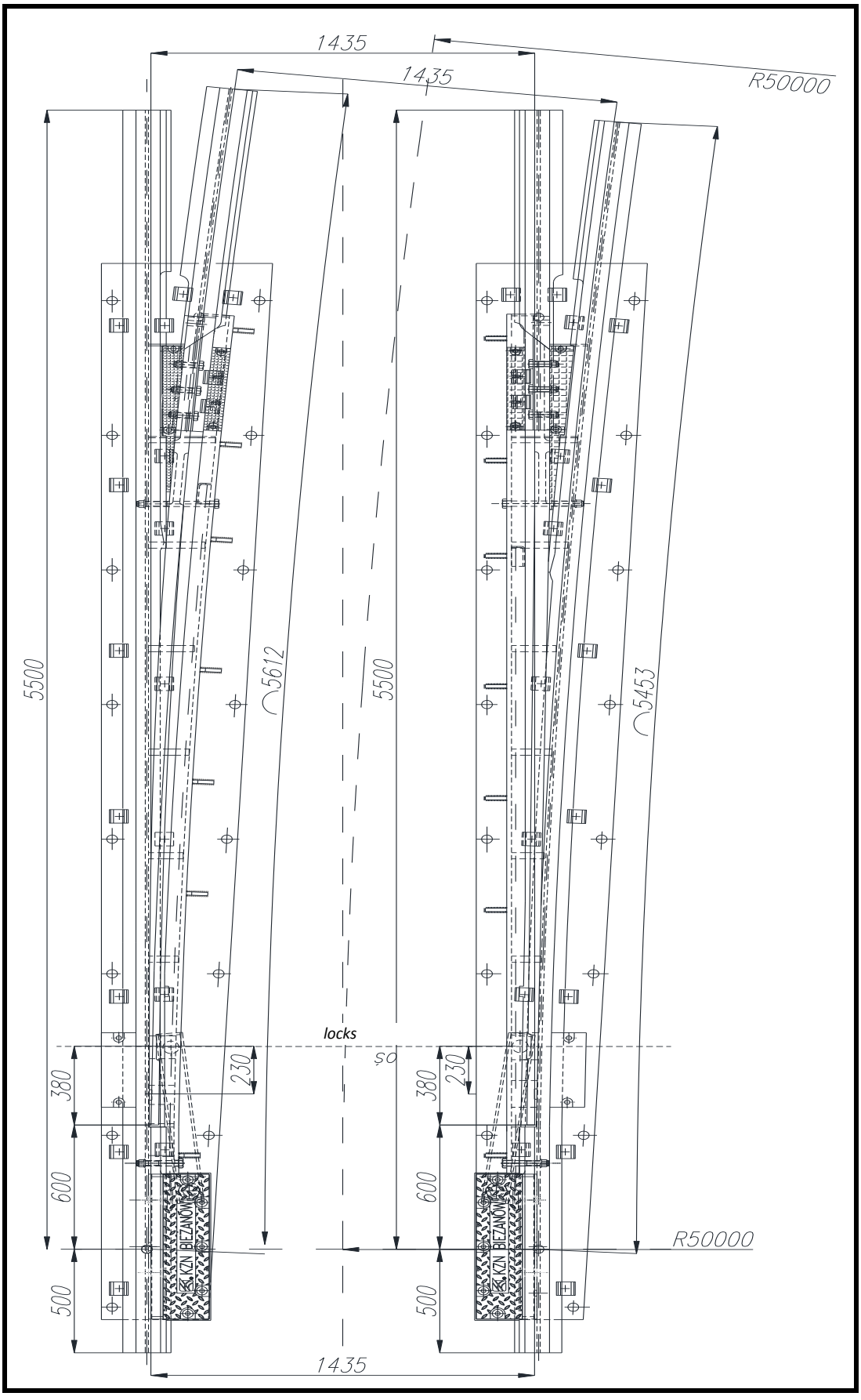


Figure 7. ZT-75-3800 R50 switch

2.3.8 Tramway switch of the ZT-75-4050 type, straight (parallel)

2.3.8.1 Technical data

- According to Table 3
- Designed for medium traffic 20-45 cars/h (600-1000 t/h) and 8Tg/year>Q≥5Tg/year

2.3.8.2 Product description

The design of the ZT-75-4050 STRAIGHT switch results from specific circumstances, in terms of track geometry, where traffic separation is required before the junction. It is connected with the turnout by a straight track with a distance of 190 mm between rail axes.

The blades are made from the R260 steel grade and installed in the switch using a method facilitating their replacement. Due to a small surface of their profiles (cross sections), the blades are supported at their entire length by a steel plate, and their initial sections are supported by two chairs that facilitate the operation of machines commonly used in Poland and abroad. The heads of the blades are surface-hardened up to 320HB (±30) to increase their useful life.

The switch is equipped with 2 sets of heating boxes installed inside by stock rails. The boxes are placed towards the face of the switch to ensure the best heating method of the blade tips.

The heating boxes are designed as casings for electrical connections with heaters and also facilitate the replacement of a damaged heater with a new one.

The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion, laid under the check rail supporting plate, nearby the blades.

Horizontal fastenings of the ends of connecting rods in the blades (a bolt and the controller tip) are covered on the external side of the switch by the inspection boxes which facilitate connecting of hooks in a switch installed in the road.

Each half of the switch is supported by a steel plate 15 mm thick, suitable for fastening on sleepers or a concrete slab.

2.3.8.3 Product manufacture formula

Our offer includes both complete turnouts and blades to replace worn components in turnouts.

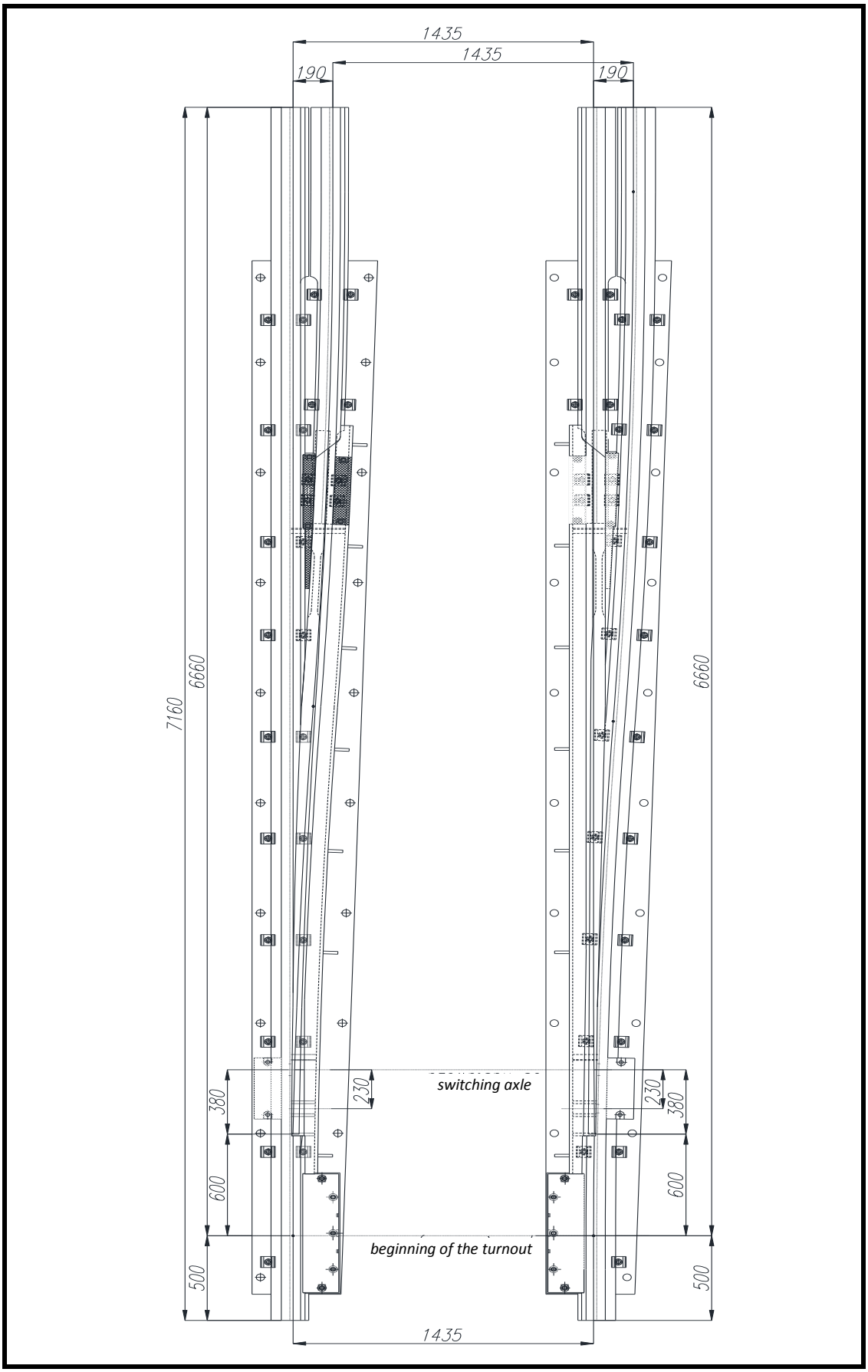


Figure 8. ZT-75-4050 R∞ (straight) switch

2.3.9 Tramway switch of the ZT-116-4206 R=50m type

2.3.9.1 Technical data

- According to Table 3
- Designed for heavy traffic 45-60 cars/h (1800 t/h) and q≥8Tg/year

2.3.9.2 Product description

The blades are made from the 49E1A1 blade profile, R350HT steel grade and installed in the switch using a method facilitating their replacement. The ends of the blades are cut at an angle of 45º, so that the vehicle leaves the blade tip according to the movement direction. Due to their massive structure, the blades are supported on their entire lengths discretely by chairs with an enhanced resistance to abrasion. The shape of blade bases in the place of their fastening in the holders is designed so as to ensure vertical pressure, achieved with the use of a wedge component that is held secure by 3 bolts with self-locking washers.

The turnout is designed to work with typical machines.

The ends of machine connecting rods are fixed using vertical components (bolts or pin), therefore the place of fastening is protected by a detachable check rail cover.

Each half of the switch is supported by a steel plate 15 mm thick, suitable for fastening on sleepers or a concrete slab.

The switches are equipped with a complete set of heating boxes installed outside the stock rails which together with the boxes enclosing the heaters along their entire lengths encase electrical connections and also facilitate replacement of damaged heaters with new ones.

The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion, laid under the stock rail head. Each half of the switch is equipped with 2 heaters.

All turnout components are protected against corrosion, except the rolling surfaces and contact surfaces between the blades and slide chairs.

2.3.9.3 Product manufacture formula

Our offer includes both complete turnouts and blades to replace worn components in turnouts.

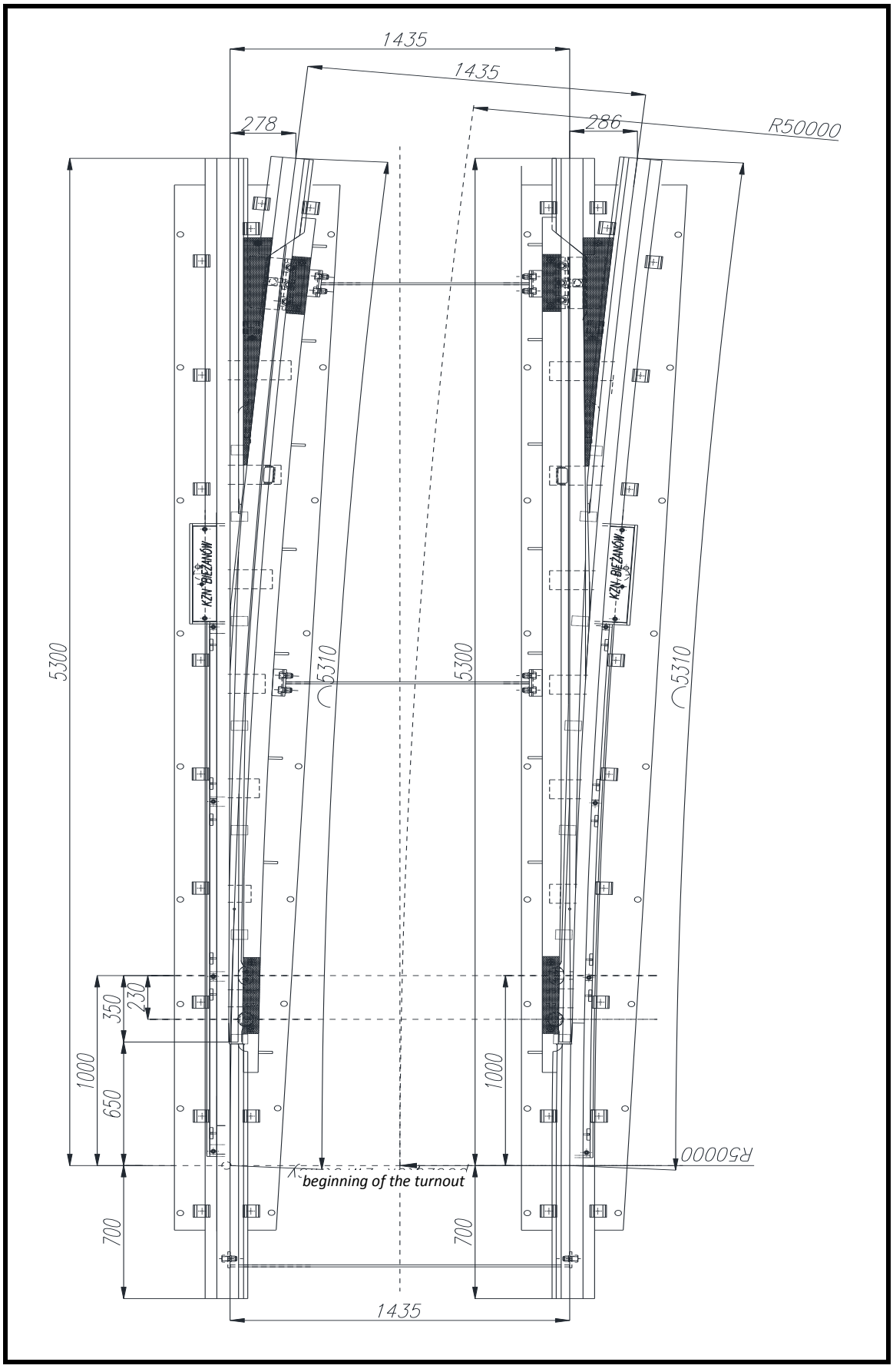


Figure 9. ZT-116-4206 R50 switch

2.3.10 Tramway switch of the ZT-116-3200 R=50m type

2.3.10.1 Technical data

- According to Table 3
- Designed for heavy traffic 45-60 cars/h (1800 t/h) and q≥8Tg/year

2.3.10.2 Product description

The blades are made from the 49E1A1 blade profile, R350HT steel grade and installed in the switch using a method facilitating their replacement. The ends of the blades are cut at an angle of 45º, so that the vehicle leaves the blade tip according to the movement direction. Due to their massive structure, the blade is supported on its entire length discretely by chairs with an enhanced resistance to abrasion.

A significant modification as compared to the ZT-116-4206 R50 switch is the blade shortened to 3200 mm and fastening with the use of a wedge with variable cross and longitudinal sections that is hammered in along the blade base in the holder and secured against undoing by a bolt with a special self-locking washer. Additionally, the machining concept of the end of the running surface of the blade is modified to achieve continuous running surface for the wheel along the stock rail.

The turnout is designed to work with typical machines.

The ends of machine connecting rods are fixed using vertical components (bolts or pin), therefore the place of fastening is protected by a detachable check rail cover.

Each half of the switch is supported by a steel plate 15 mm thick, suitable for fastening on sleepers or a concrete slab.

The switches are equipped with a complete set of heating boxes installed outside the stock rails which together with the boxes enclosing the heaters along their entire lengths encase electrical connections and also facilitate replacement of damaged heaters with new ones.

The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion, laid under the stock rail head. Each half of the switch is equipped with 2 heaters.

All turnout components are protected against corrosion, except the rolling surfaces and contact surfaces between the blades and slide chairs.

2.3.10.3 Product manufacture formula

Our offer includes both complete turnouts and blades to replace worn components in turnouts.

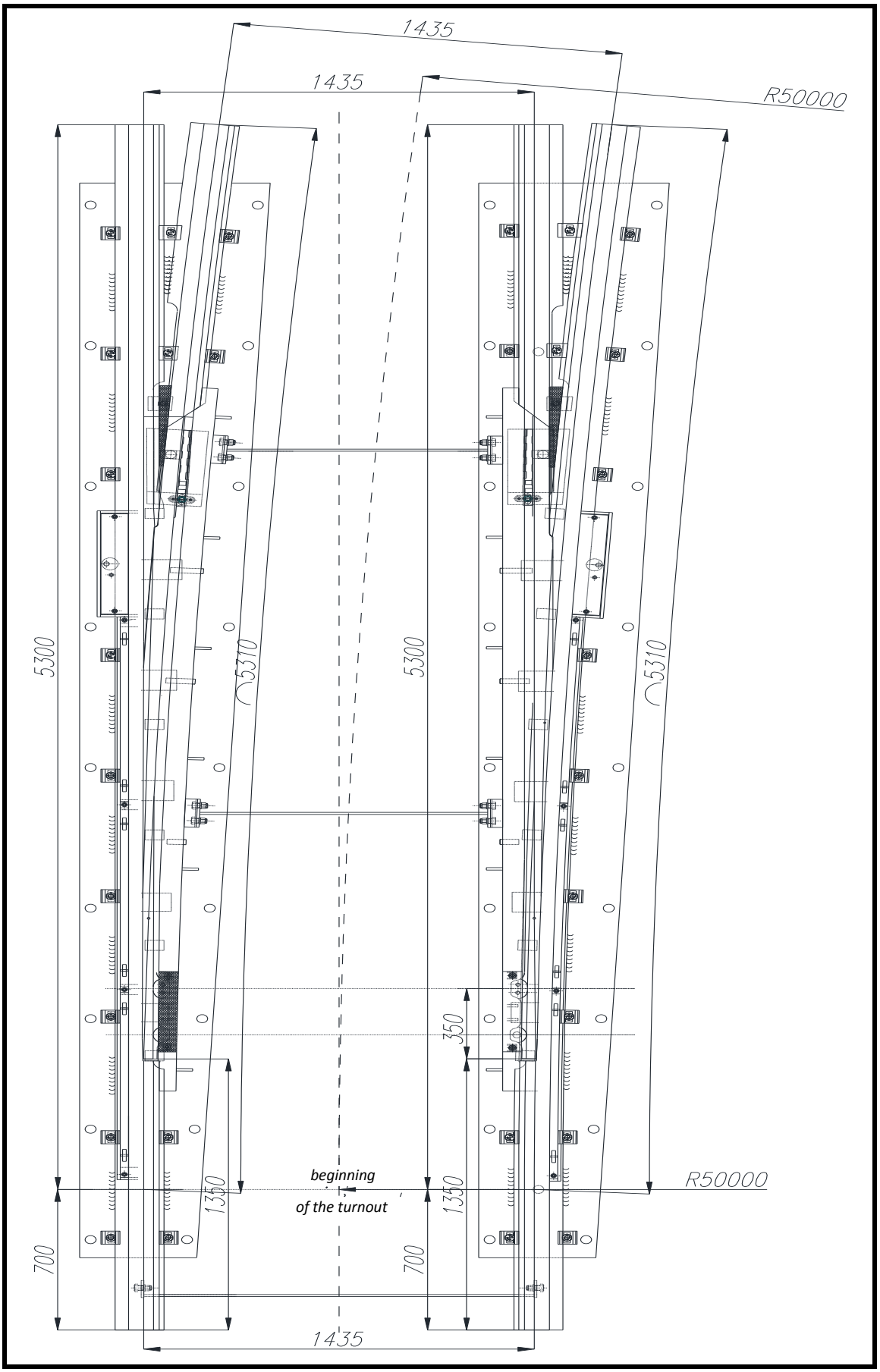


Figure 10. ZT-116-3200 R50 switch

2.3.11 Tramway switch of the ZT-116-3200 R=25m type

2.3.11.1 Technical data

- According to Table 3
- Designed for medium traffic 20-45 cars/h (600-1000 t/h) and q≥5Tg/year

2.3.11.2 Product description

The blades are made from the 49E1A1 blade profile, R350HT steel grade and installed in the switch using a method facilitating their replacement. The ends of the blades are cut at an angle of 45º, so that the vehicle leaves the blade tip according to the movement direction. Due to their massive structure, the blade is supported on its entire length discretely by chairs with an enhanced resistance to abrasion.

The blades are fixed in this turnout using screwed down wedges. The machining concept of the end of the contact surface of the blade is modified to achieve a continuous bearing surface for the wheel along the stock rail.

The turnout is designed to work with typical machines.

The ends of machine connecting rods are fixed using vertical components (bolts or pin), therefore the place of fastening is protected by a detachable check rail cover.

Each half of the switch is supported by a steel plate 15 mm thick, suitable for fastening on sleepers or a concrete slab.

The switches are equipped with a complete set of heating boxes installed outside the stock rails which together with the boxes enclosing the heaters along their entire lengths encase electrical connections and also facilitate replacement of damaged heaters with new ones.

The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion, laid under the stock rail head. Each half of the switch is equipped with 2 heaters.

All turnout components are protected against corrosion, except the rolling surfaces and contact surfaces between the blades and slide chairs.

2.3.11.3 Product manufacture formula

Our offer includes both complete turnouts and blades to replace worn components in turnouts.

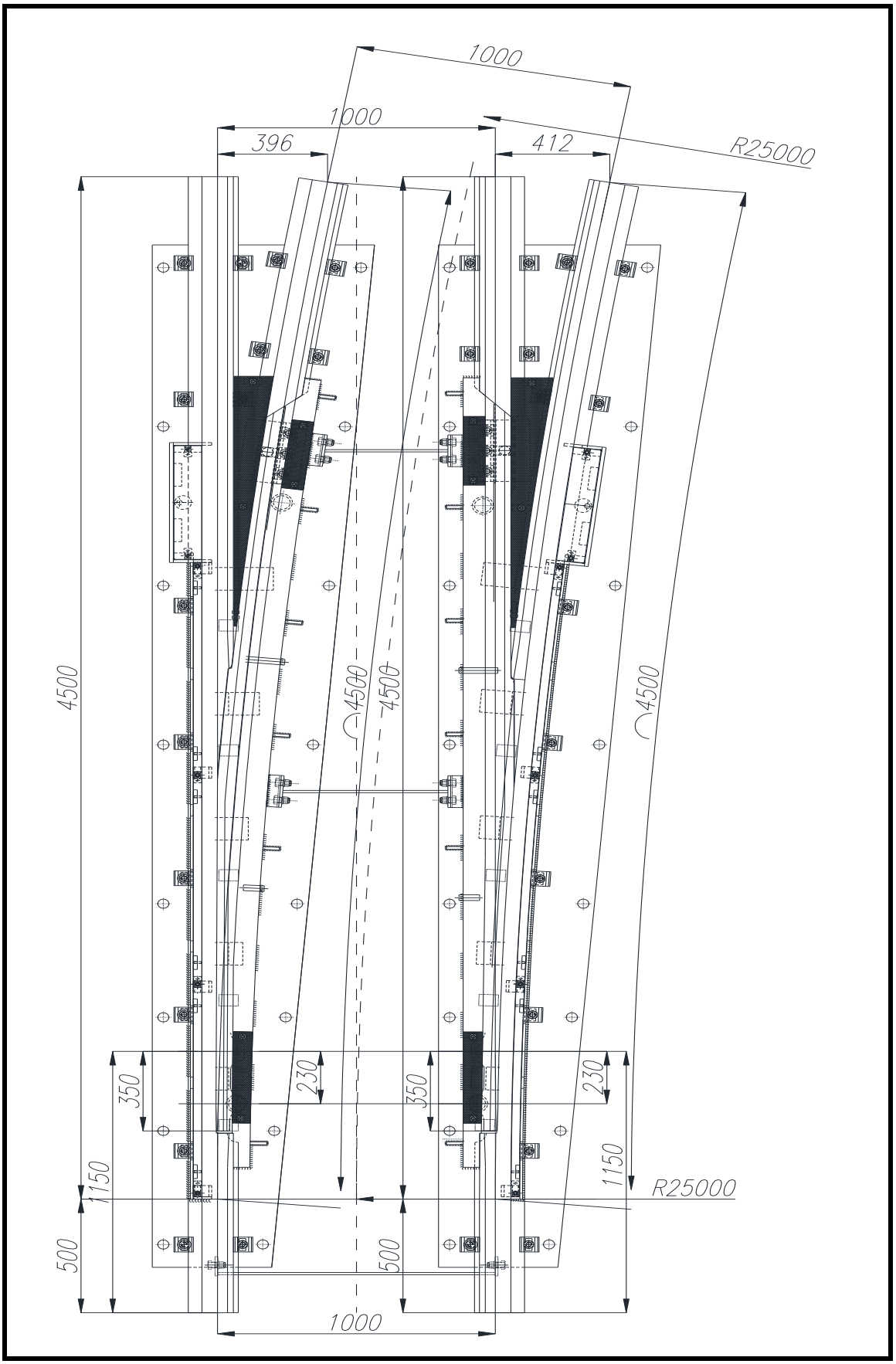


Figure 11. ZT-116-3200 R25 switch

2.3.12 Tramway switch of the ZT-116-5450 type, straight (parallel)

2.3.12.1 Technical data

- According to Table 3
- Designed for heavy traffic 45-60 cars/h (1800 t/h) and q≥8Tg/year

2.3.12.2 Product description

The design of the ZT-116-5450 STRAIGHT switch results from specific circumstances, in terms of track geometry, where traffic separation is required before the junction. It is connected with the turnout by a straight track situated at a distance of 113 mm.

The blades are made from the 49E1A1 blade profile, R350HT steel grade and installed in the switch using a method facilitating their replacement. The ends of the blades are cut at an angle of 45º, so that the vehicle leaves the blade tip according to the movement direction. Due to their massive structure, the blade is supported on its entire length discretely by chairs with an enhanced resistance to abrasion.

The turnout is designed to work with typical machines.

The ends of machine connecting rods are fixed using vertical components (bolts or pin), therefore the place of fastening is protected by a detachable check rail cover.

Each half of the switch is supported by a steel plate 15 mm thick, suitable for fastening on sleepers or a concrete slab.

The switch is equipped with 4 sets of heating boxes installed outside stock rails on their heads side. The heating boxes are designed as casings for electrical connections with heaters and also facilitate the replacement of a damaged heater with a new one. The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion. 4 tubes are installed in each half of the switch, separated from each other at their entire lengths. If one heater is damaged, the other may be connected. The protective tubes are installed in a duct that significantly reduces the inflow of stormwater.

2.3.12.3 Product manufacture formula

Our offer includes both complete turnouts and blades to replace worn components in turnouts.

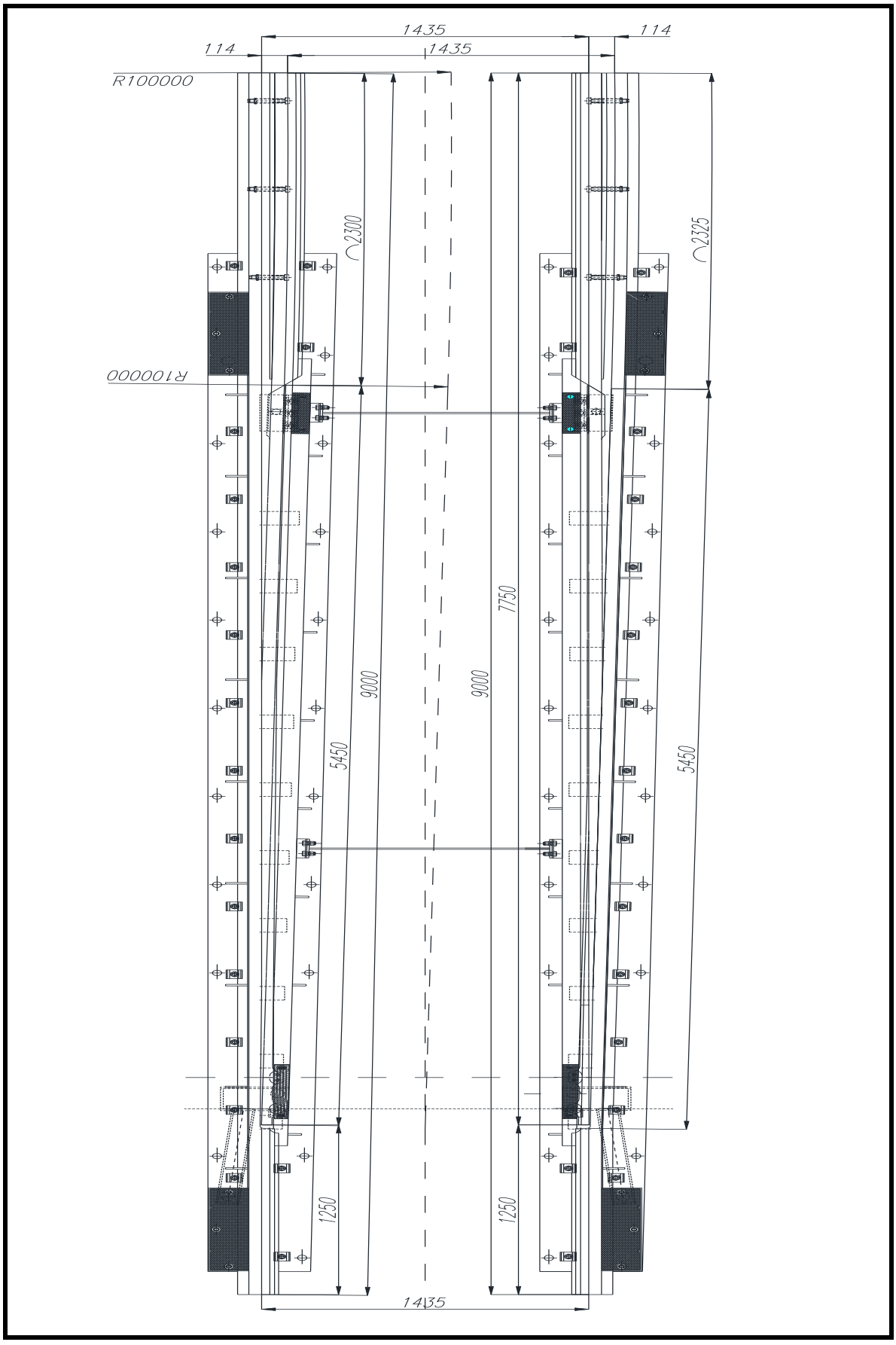


Figure 12. ZT-116-5450 R∞ switch (straight)

2.3.13 Tramway switch of the ZT-116-4900 R=100m type

2.3.13.1 Technical data

- According to Table 3
- Designed for heavy traffic 45-60 cars/h (1800 t/h) and q≥8Tg/year

2.3.13.2 Product description

The blades are made from the 49E1A1 blade profile, R350HT steel grade and installed in the switch using a method facilitating their replacement. The ends of the blades are cut at an angle of 45º, so that the vehicle leaves the blade tip according to the movement direction. Due to their massive structure, the blade is supported on its entire length discretely by chairs with an enhanced resistance to abrasion.

The blades are fixed in this turnout using screwed down wedges. The machining concept of the end of the contact surface of the blade is modified to achieve a continuous bearing surface for the wheel along the stock rail.

The turnout is designed to work with typical machines.

The ends of machine connecting rods are fixed using vertical components (bolts or pin), therefore the place of fastening is protected by a detachable check rail cover.

Each half of the switch is supported by a steel plate 15 mm thick, suitable for fastening on sleepers or a concrete slab.

The switches are equipped with a complete set of heating boxes installed outside the stock rails which together with the boxes enclosing the heaters along their entire lengths encase electrical connections and also facilitate replacement of damaged heaters with new ones.

The switch is heated using electrical heaters installed in protective tubes ø25 made from steel resistant to corrosion, laid under the stock rail head. Each half of the switch is equipped with 2 heaters.

All turnout components are protected against corrosion, except the rolling surfaces and contact surfaces between the blades and slide chairs.

2.3.13.3 Product manufacture formula

Our offer includes both complete turnouts, turnout halves, and blades to replace worn components in turnouts.

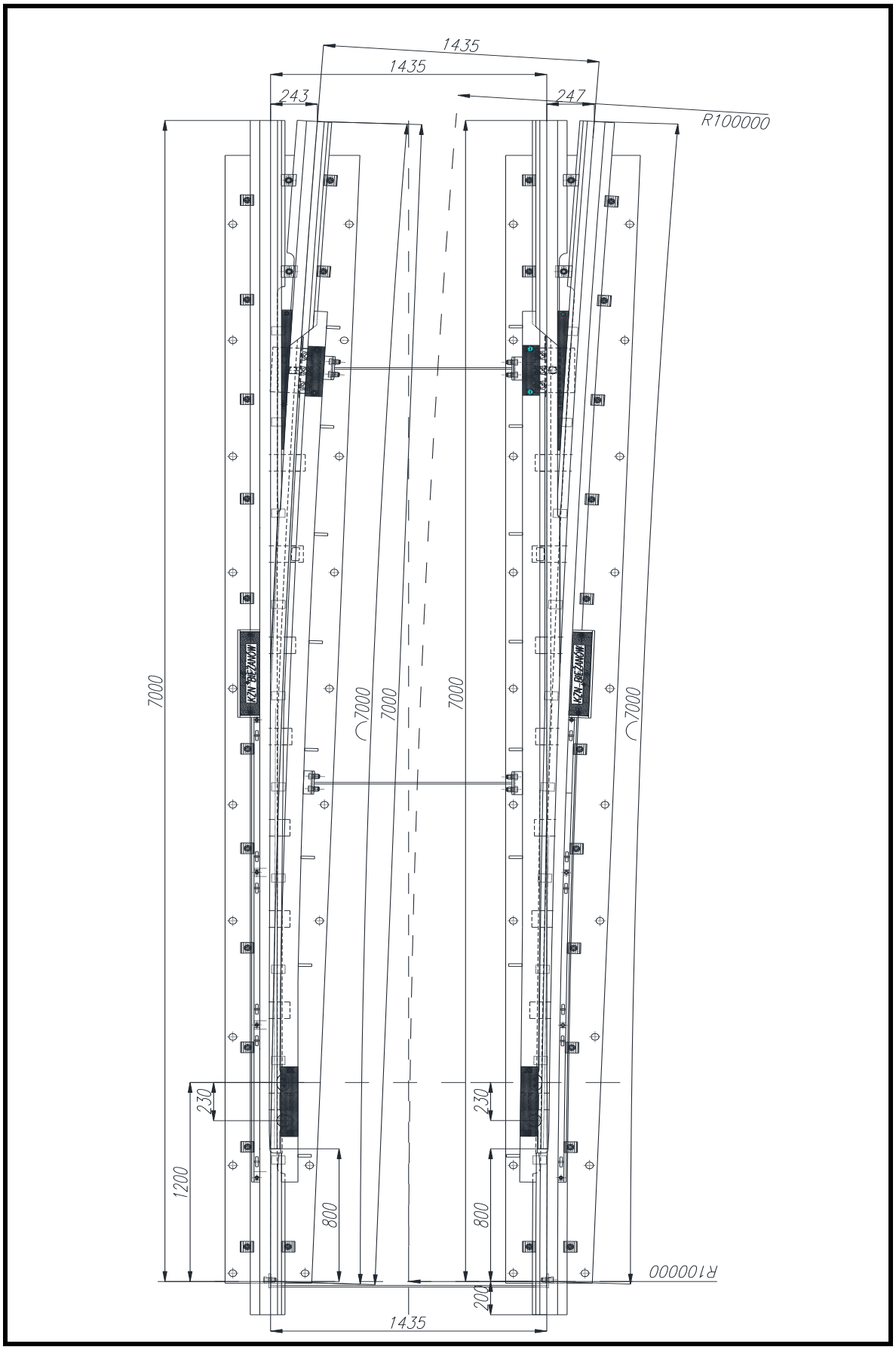


Figure 13. ZT-116-4900 R100 switch

2.3.14 Disk blade

2.3.14.1 Technical data

- Replaceable blade
- Blade height 68 mm
- Blade length 2600
- Material – steel R260 grade

2.3.14.2 Product description

These blades are manufactured only to replace switches installed before 2005.

2.4 Frogs

2.4.1 Technical characteristics of the frogs

A frog consists of a frog block and four grooved rails welded to it. A frog may be designed as:

- a full cast steel block
- a layered steel block in which the surface layer is made from a steel plate characterised by high strength and resistance to abrasion, welded onto the lower layer,
- a box structure with its surface layer made from steel plate characterised by high strength and resistance to abrasion.

Geometricl and structural properties of these components and the layout of the entire frog zone influence the technical characteristics of frogs described in the following sections.

2.4.2 Types of frogs in turnouts

The following types of frogs are distinguished, depending on the layout of the frog zone in a turnout or track junction and the resultant shapes of running and guiding surfaces:

- Common frogs in which the wheel set is guided along the length of track discontinuity (discontinuity of running and guiding surfaces) in the frog block by the check rail that constitutes an opposite stretch of rails – the situation of running surfaces in a common frog is shown in **Figure 14a**;

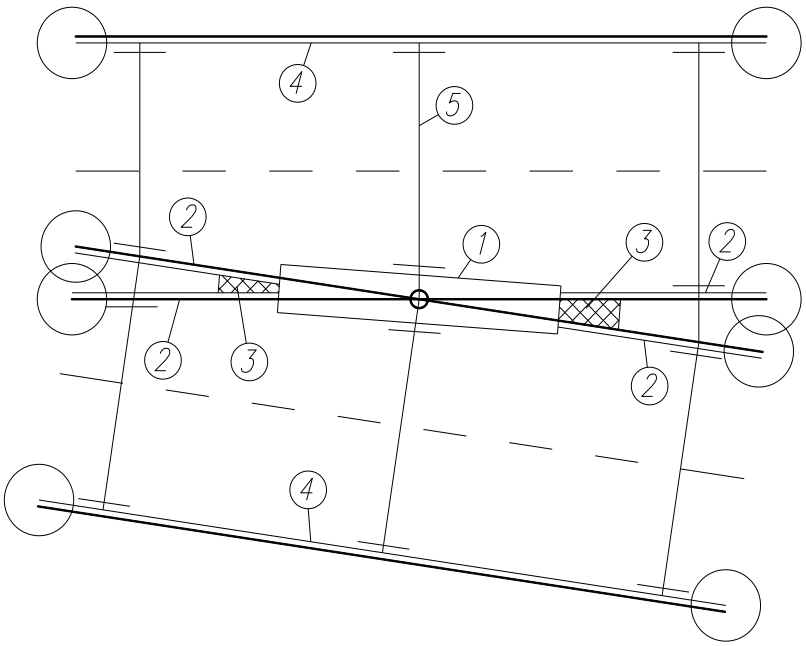


Figure 14a. Situation of running surfaces in a common frog: 1- frog block, 2- rails welded onto the frog block, 3- filling block, 4- check rail, 5- stretcher bar

- Double frogs in which the wheel set is guided along the length of track discontinuity (discontinuity of running and guiding surfaces) in one of the frog blocks by the guiding edge of the second frog block situated in the opposite track – the situation of running surfaces in double frogs is shown in **Figure 14b**;

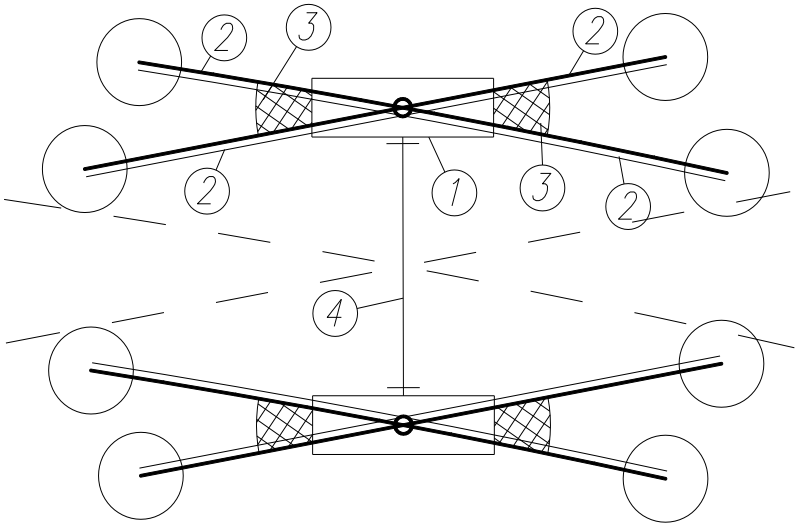


Figure 14b. Situation of running surfaces in a double frog: 1- frog block, 2- rails welded onto the frog block, 3- filling block, 4- stretcher bar

2.4.3 Two-layer shallow-groove solid frog

This layered structure of the frog has successfully been implemented in numerous locations, such as the cities of Kraków, Wrocław, Warsaw, Łódź, Toruń and Bytom, and it meets all technical requirements set by the customers.

This type of design is characterised by the application, as the surface layer in which running grooves are completed, of a steel plate with increased resistance to abrasion and surface load.

The surface layer, having a direct contact with the wheel, is welded along its entire perimeter onto a lower steel block and to shallow-groove rails installed as the access to the frog. The height of the frog is adapted to the height of the rails used in turnouts.

		Hardox HiTuf	Hardox 400	Hardox 450	Hardox 500	Hardox 550	Hardox 600
Hardness	HB	310÷370	370÷430	425÷475	470÷540	525÷575	570÷640
$R_{p0,2}$	MPa	950÷850	1000	1200	1300	1400	1650
R_m	MPa	980÷900	1250	1400	1550	1700	2000
A_5	%	16	10	10	8	7	7
KV_{-40}	J	95÷70	45	40	30	30	20

Table 4 Selected mechanical properties of the Hardox steel according to data provided by the manufacturer

The

Access and closure rails are made from the 76C1 or 105C1 rail profile (according to PN EN 14811:2006), in which a running grove is milled with a trapezoid cross-section with side walls inclined 1:6. The depth of the groove in closure rails is 12 mm and a ramp is made in the access rails, inclined 1:100 at a length of 1000 mm. The surfaces of the access and closure rails are tempered to achieve a hardness of 300–360HB.

As a result of materials used, characterised by good resistance to abrasion and good mechanical properties, the solid frog is the best solution for tracks with heavy traffic and exposed to large stresses and loads.

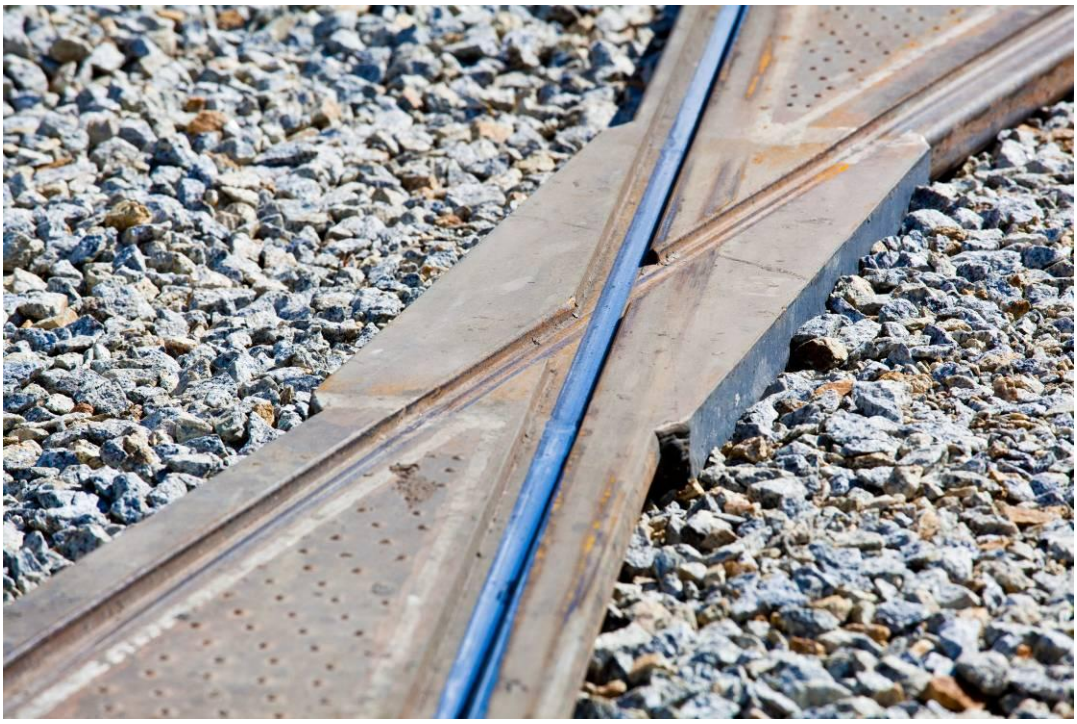


Figure 14. Two-layer solid frog

2.4.4 Shallow-groove solid frog made from the 310C1 profile

The solid frog made from the 310C1 profile, welded to 76C1 or 105C1 rails, is a solution commonly used in tramway tracks. The running grove is milled to the depth of 12 mm (or another requested by the customer) with side walls inclined 1:6. The approach rails are inclined 1:100 at a length of 1000 mm. The surface of the frog is thermally treated to achieve a minimum hardness of 300 HB and the approach and closure rails to achieve 360HB.
The connection points of the massive block with rails is additionally strengthened using metal sheet which also facilitates fastening of the entire structure to a concrete slab or sleepers.

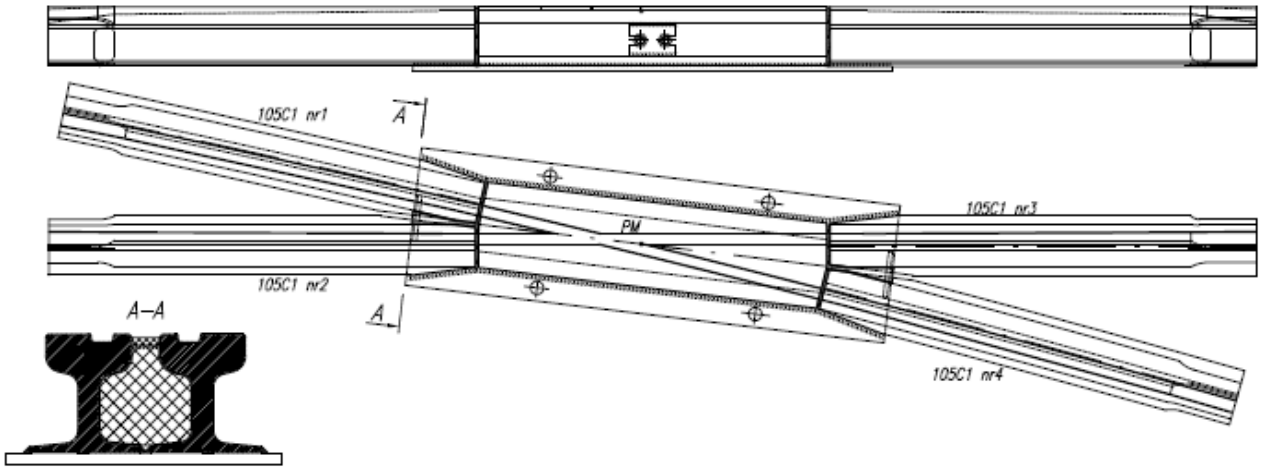


Figure 15. Two-layer solid frog

2.5 Track equipment

2.5.1 Expansion joints

2.5.1.1 Technical characteristics of expansion joints

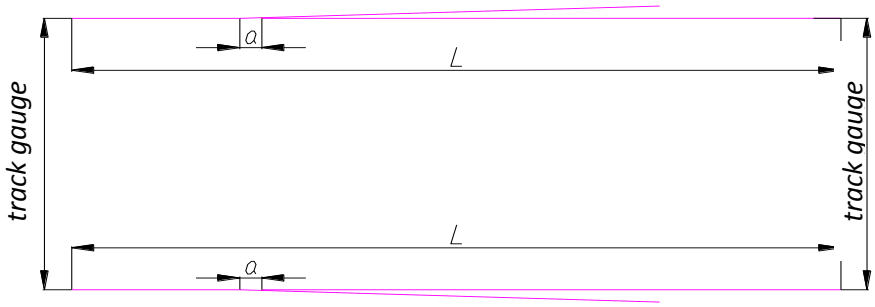


Figure 16. Schematic diagram of an expansion joint – characteristic dimensions

Rail type	***49E1***	***60R2***	***53R1***	***LK1***
Steel grade	R260 grade	R260 grade	R260 grade	R260 grade
a*[mm]	100	100	100	100
L1**[mm]	3500	3500	5100	3670

***design extension for the temperature of installation of the expansion joint 17-22°C (ambient temperature)**
****length L for an extended joint (a=100 mm)**
Track gauge –1435 mm or 1000 mm

Table 5. A list of main parameters of expansion joints

2.5.1.2 Main components of expansion joints

The main components of expansion joints include: blades and stock rails. Expansion joints may be additionally equipped with drainage boxes.

Expansion joints designed for the following rail types may be distinguished:

- 60R2 rails
- 49E1 rails
- 53R1 rails
- LK1 block grooved rails

Expansion joints may be installed on wooden or steel sleepers, or on a concrete slab, or on a concrete and bitumen slab used as the track foundation. The expansion joint is fastened to the sleepers and slabs in accordance with design documents provided by the customer and its purpose is to prevent transverse and longitudinal (vertical and horizontal) movements of fixed track structure components exposed to the effects of tram traffic, changes of rail temperature and vehicular traffic.

2.5.2 An expansion joint made from 60R2 rails

2.5.2.1 Technical data

rail type – 60R2 from R260 steel grade
L=3500 mm
a=100 mm

Expansion joints made from 60R2 rail profiles may be installed both on wooden or steel sleepers and on a concrete slab or on a concrete and bitumen slab used as the track foundation.

The main components of the expansion joint are the blade and the stock rail fastened to supporting sheet using a method that ensures their axial shift. Rated extension (location of the blade tip relative to the stock rail) is determined for a temperature of 17-22°C during assembly at the manufacturer's plant for 100 mm. The length defined at rated extension is 3500 mm.

An important feature of this design is stress control achieved by shifts of both the blade and the stock rail.

Expansion joints may be additionally equipped with a drainage box and metal-plate screens at the customer's request. Information about additional equipment and rail grade should be provided by the customer.

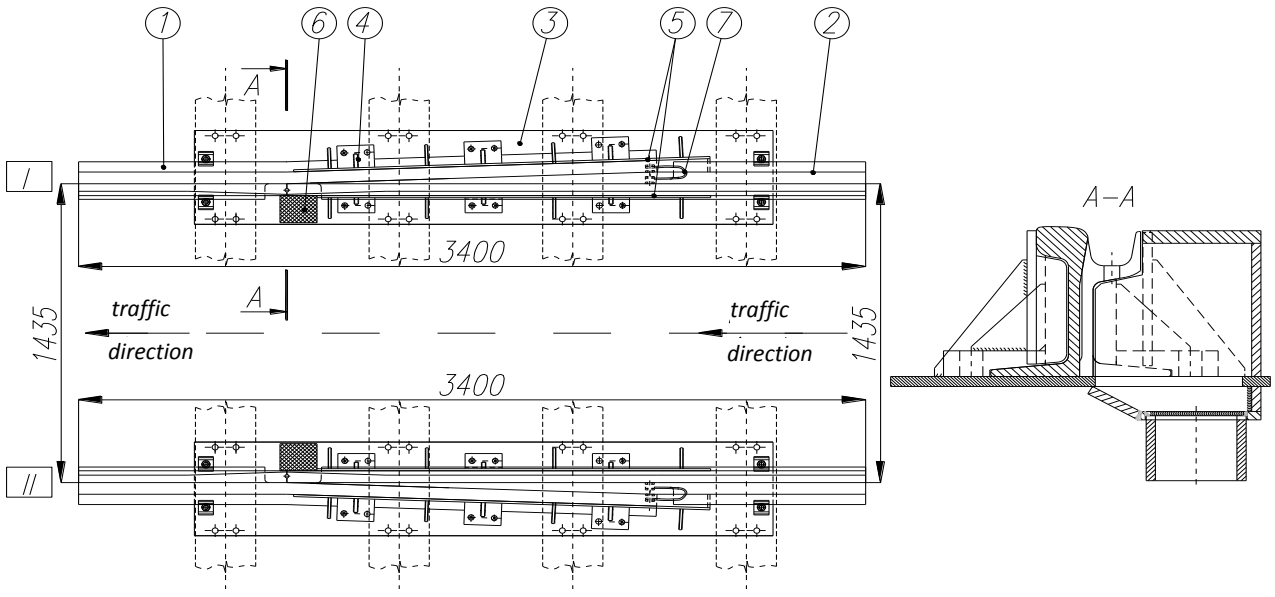


Figure 16. An expansion joint made from 60R2 rails: I- left expansion joint, II- right expansion joint, 1- stock rail, 2- blade, 3- supporting plate, 4- fastening supports, 5- plate screens, 6- drainage box, 7- cable connection

2.5.3 An expansion joint made from 49E1 rails

2.5.3.1 Technical data

rail type – 49E1 from R260 steel grade
L=3500 mm
a=100 mm
Expansion joints made from 49E1 rail profiles are designed for installation in separated tracks on wooden sleepers used in the track structure.

The main components of the expansion joint are the blade and the stock rail fastened to supporting sheet using a method that ensures their axial shift. Rated extension (location of the blade tip relative to the stock rail) is determined for a temperature of 17-22°C during assembly at the manufacturer's plant for 100 mm. The length defined at rated extension is 3500 mm. An important feature of this design is stress control achieved by shifts of both the blade and the stock rail.

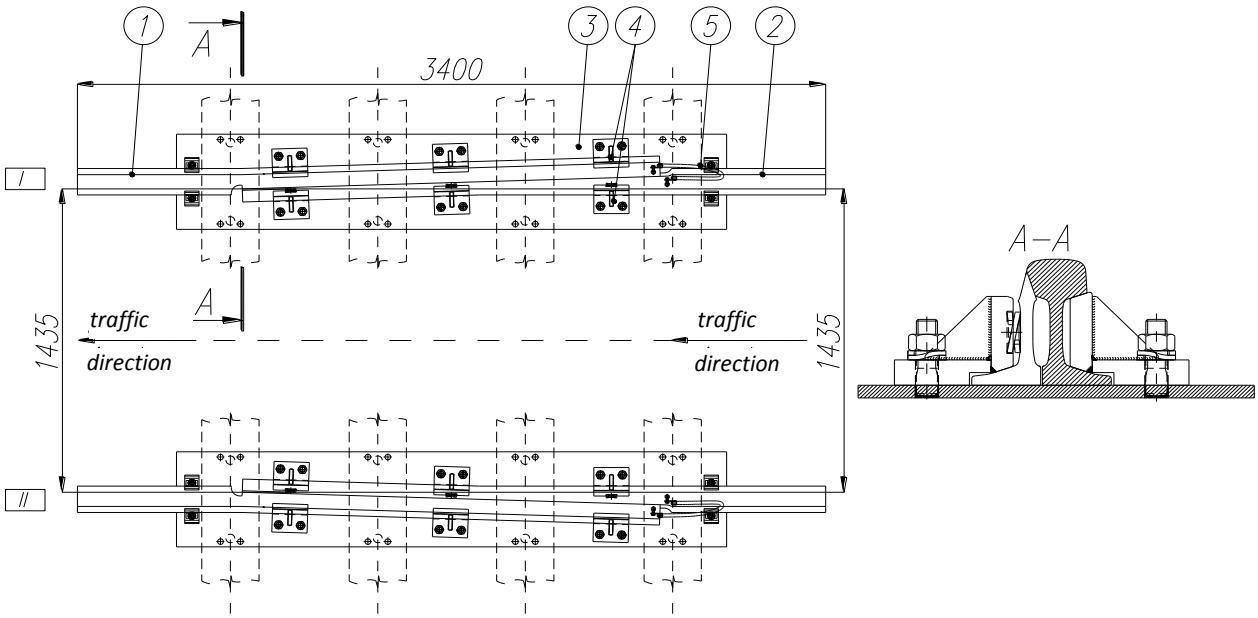


Figure 17. An expansion joint made from 49E1 rails: I- left expansion joint, II- right expansion joint, 1- stock rail, 2- blade, 3- supporting plate, 4- fastening supports, 5- cable connection

2.5.4 An expansion joint made from 53R1 rails

2.5.4.1 Technical data

rail type – 53R1 from R260 steel grade

L=3500 mm

a=100 mm

Expansion joints made from 53R21 rail profiles may be installed both on wooden or steel sleepers and on a concrete slab or on a concrete and bitumen slab used as the track foundation.

The main components of the expansion joint are the blade and the stock rail fastened to supporting sheet using a method that ensures their axial shift. Rated extension (location of the blade tip relative to the stock rail) is determined for a temperature of 17-22°C during assembly at the manufacturer's plant for 100 mm. The length defined at rated extension is 3500 mm.

An important feature of this design is stress control achieved by shifts of the blade at fixed stock rail.

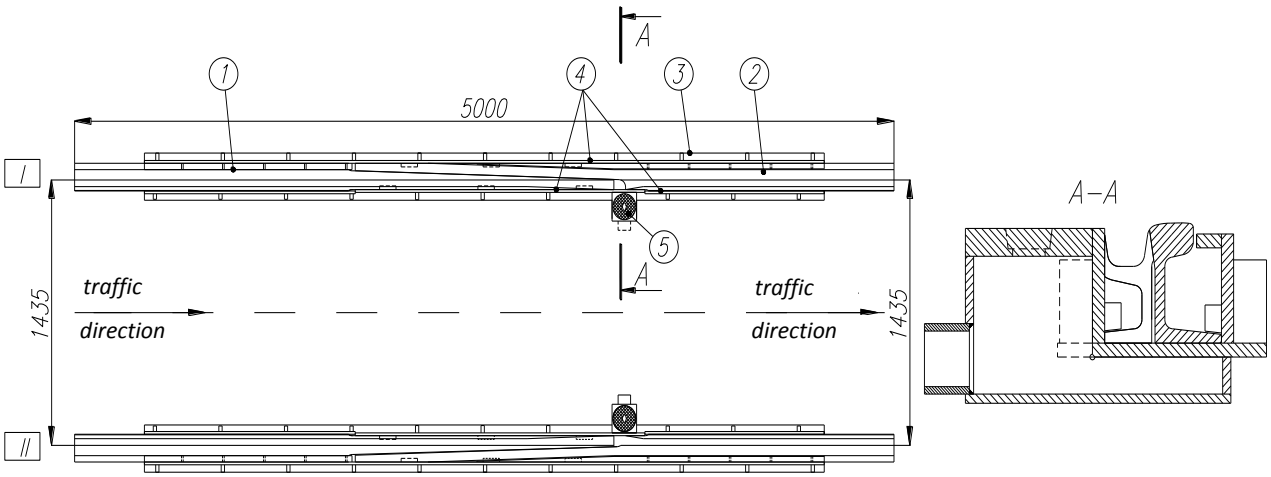


Figure 18. An expansion joint made from 53R1 rails: I- right expansion joint, II- left expansion joint, 1- blade, 2- stock rail, 3- supporting plate, 4- plate screens, 5- drainage box

2.5.5 An expansion joint made from LK 1 block grooved rails

2.5.5.1 Technical data

rail type – LK1
L=3570 mm (put together)
a=100 mm

Expansion joints made from LK1 profile block rails are used to construct tracks from grooved rails installed in a concrete foundation.

The main components of the expansion joint are the blade and the stock rail connected using a method that ensures their shifts along the track axis. Rated expansion (location of the blade tip relative to the stock rail) for a temperature of 17-22°C is 100 mm. The installation length defined for a joint put together is 3570 mm.

An important feature of this design is stress control achieved by shifts of both the blade and the stock rail.

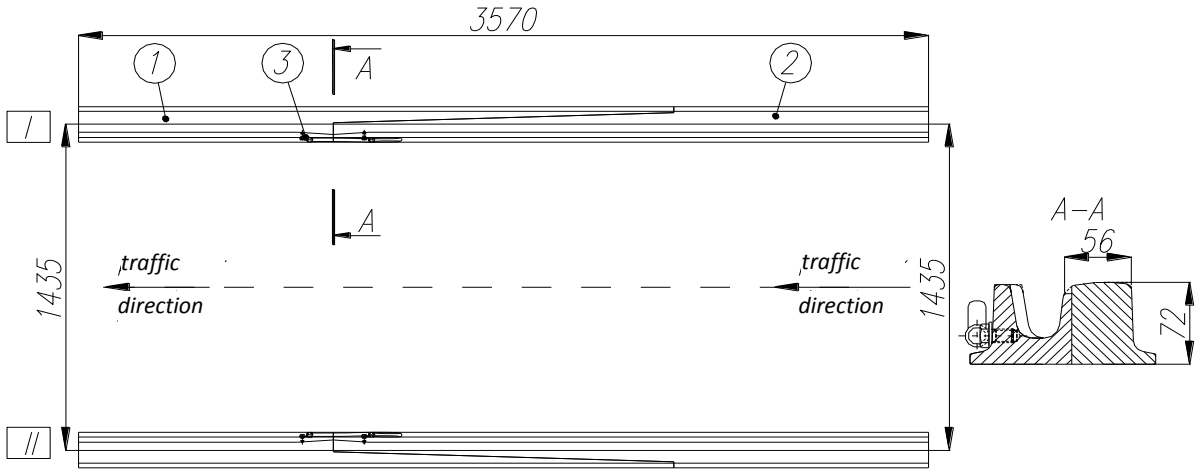


Figure 19. An expansion joint made from LK 1 block grooved rails: I- left expansion joint, II- right expansion joint, 1;1’- stock rail, 2;2’- blade, 3;3’- cable connection

2.5.6 Connecting rails

2.5.6.1 Technical characteristics of connecting rails

Connecting rails may be installed on wooden or steel sleepers, or on a concrete slab, or on a concrete and bitumen slab used as the track foundation. The expansion joint is fastened to the sleepers and slabs in accordance with design documents provided by the customer and its purpose is to prevent transverse and longitudinal (vertical and horizontal) movements of fixed track structure components exposed to the effects of tram traffic, changes of rail temperature and vehicular traffic.

The following types of connecting rails may be distinguished:

- 60R2 – 49E1 connecting rail (ver. I – welded)
- 60R2 – 49E1 connecting rail (ver. II – with bolted joints)
- 60R2 – LK1 connecting rail

2.5.7 60R2 – 49E1 connecting rail (ver. I – welded)

The profile change takes place along a specially designed intermediate insert, usually made from the 49E1F1 profile (**Figure 20**),

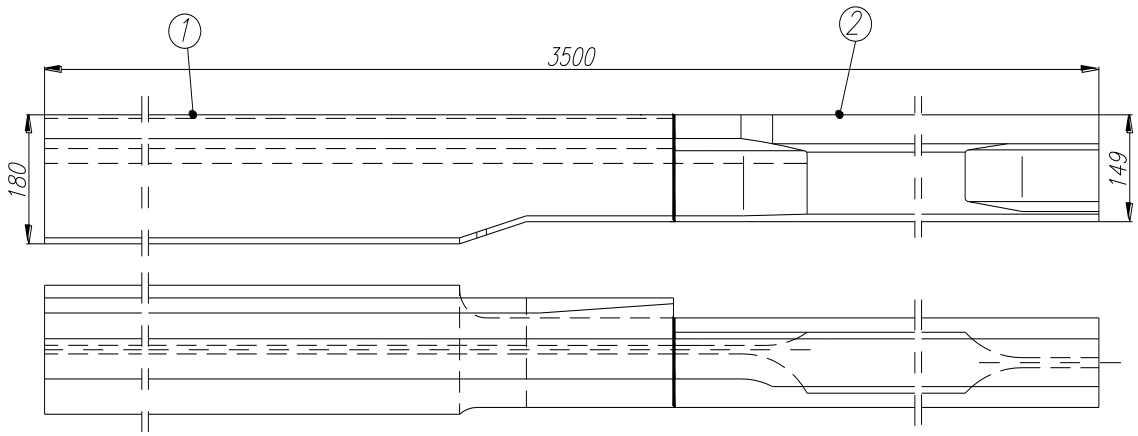


Figure 20. 60R2 / 49E1 connecting rail (ver.I): 1- 60R2 rail, 2- 49E1F1 profile.

2.5.8 60R2 – 49E1 connecting rail (ver. II – with bolted joints)

The profile is changed directly from a 60R2 rail into a 49E1 rail without the use of intermediate rail components. The ends of the rails in the connection point are appropriately machined to match, and the connection is completed using bolted joints (Figure 21),

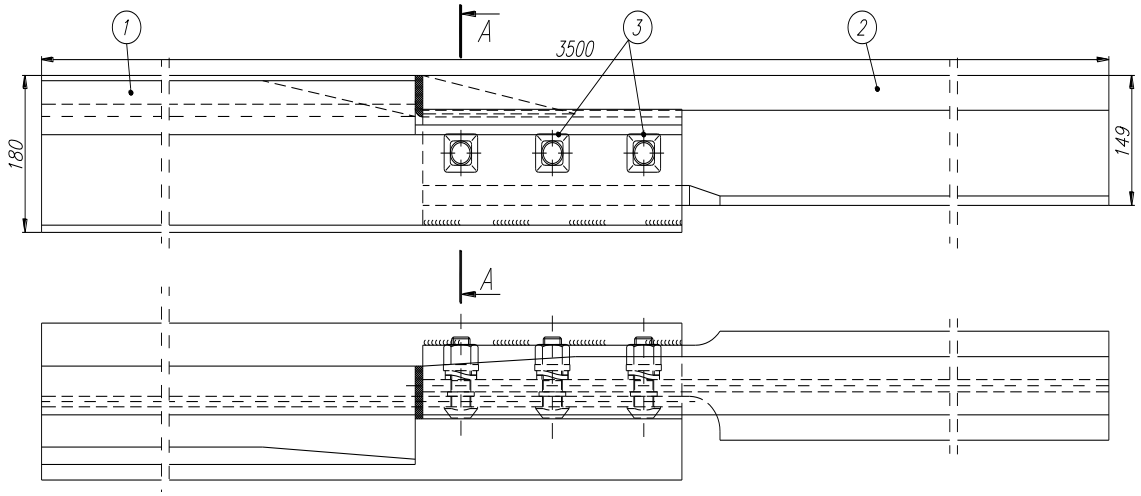


Figure 21. 60R2 / 49E1 connecting rail (ver.II): 1- 60R2 rail, 2- 49E1 rail, 3- bolted joint

2.5.9 60R2 – LK1 connecting rail,

The profile is changed in the welded joint in the contact point of two rail ends (Figure 22).

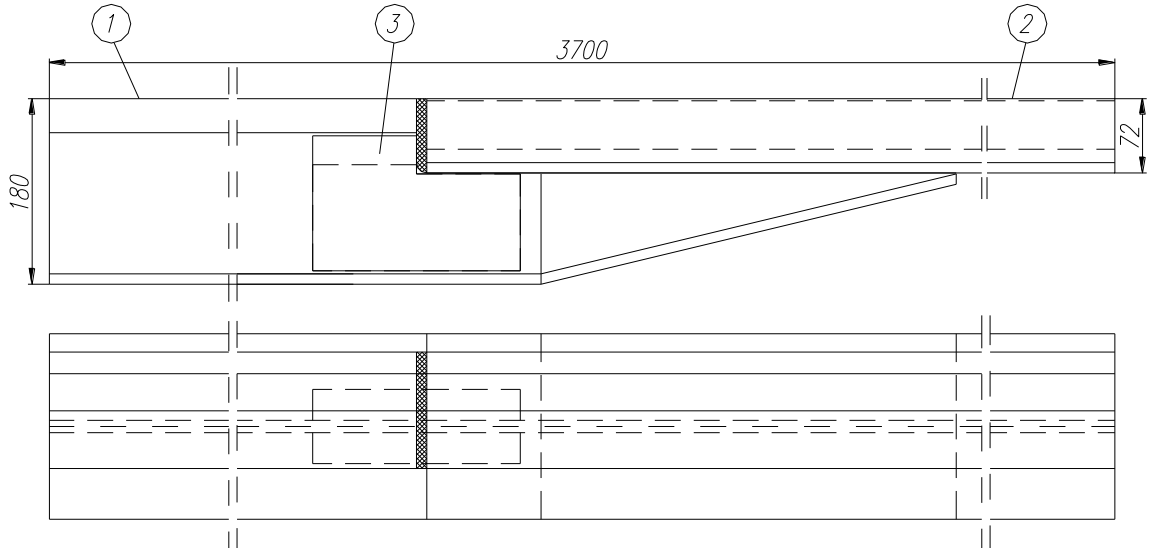


Figure 22. 60R2 / LK1 connecting rail: 1- 60R2 rail, 2- LK1 block rail, 3- strengthening fish plates

2.6 Overlapping (temporary) turnout

2.6.1 Technical data

- Design based on LK1 block rails
- Turnout radius – R50m
- Turnout angle – 1:6
- Track gauge – 1435 mm
- Turning angle - 9°27’44”
- Minimum distance between track axes – 2,9m
- Structure height – 92 mm
- Total length – 37.7m (at a distance of 2.9m)

2.6.2 General information

An overlapping turnout is a track structure used as a temporary, by-pass turnout system, installed usually for the time of repair works, to ensure an uninterrupted traffic of tram rolling stock. It is installed in an existing track (the main track) with the straight path consistent with the predominant direction of traffic on the track and the diverging path installed in its major part in the midway between the tracks and at its end joins the track of the other, opposite direction.

2.6.3 Structure of the overlapping turnout

The overlapping turnout consists of segments facilitating its installation in double tracks with various spacing between axes, beginning from 2.9m. The turnout is adapted to the existing spacing of track axes by elongated or shortened diverging path.

In its basic version, the overlapping turnout consists of 12 segments with fixed lengths:

- Entry / exit segments – (3 items) are designed to provide entrance into the turnout from the existing track
- A switch with an automated lock (1 item) changes the direction of traffic from the straight path into the diverging path or vice versa
- Closure rails (6 items) connect the switch and the frog with entry segments
- A frog with a check rail (1 item) makes possible movement through the junction of tracks
- The check rail (1 item) is designed as the second track in the diverging path along the frog segment

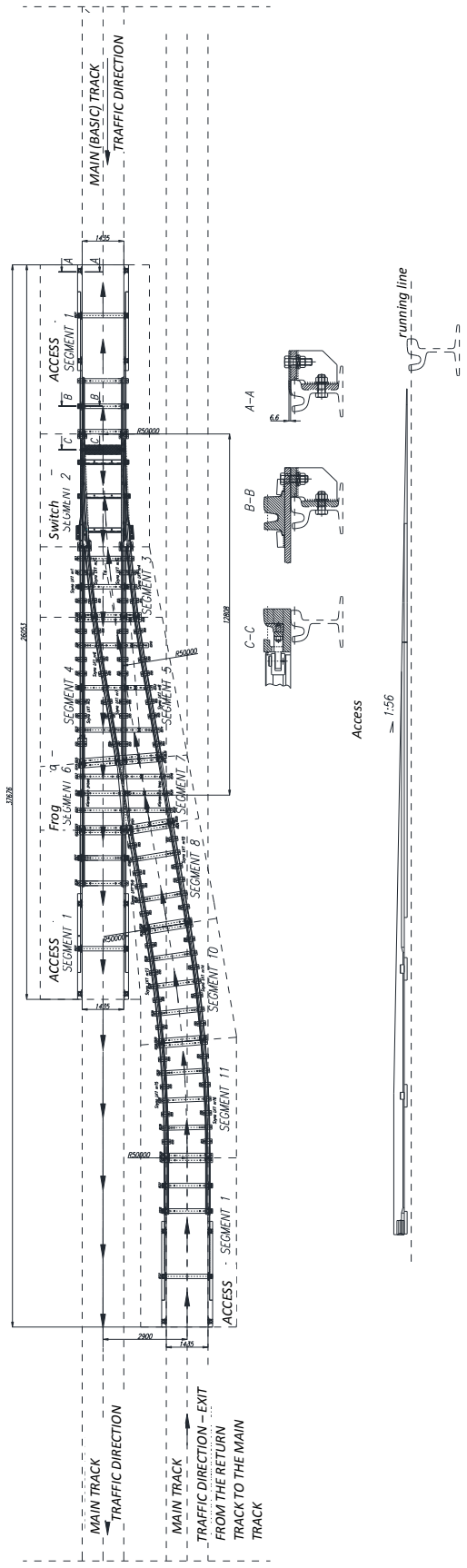


Figure 23. The layout of an overlapping turnout in the main track

2.7 SZZT-1 spring lock of a tramway turnout

2.7.1 Technical data

Track gauge	1435 mm
Blade travel	36-60 mm
Joint of the connecting (switching) rod – bolted (depending on turnout type)	M27 / 2x M16
Pressure force of the spring mechanism	0.9-3.1kN
Torque at manual switching	150-450Nm
Allowed load acting on the cover of the box	12,000 kg
Weight of the cover	61kg
Total weight	ca. 250kg

The SZZT-1 lock is designed for entry or exit switches with manual switching for the track gauge of 1435 mm. The structure of the box is made from metal plates 15 mm wide and is equipped with a drainage system in the lower section of the body. The cover is made from a metal plate 20 mm thick. The blades are moved in entry switches using a bar inserted through an opening in the cover into the control rod lever. The required force of switching and pressure is ensured by two spiral pull springs installed symmetrically on both sides of the control rod. Spring tensioners are used to adjust the spring pulling force. The control rod is equipped with articulated joints on both ends to facilitate lock operation. 2 turnbuckles mounted on both sides of the lever are provided to adjust the lengths of the rod segments. A hydraulic suppressor is applied in the lock to minimize the noise caused by blade closing. Installed in the exit switches, the lock meets the requirement for trailing movement.

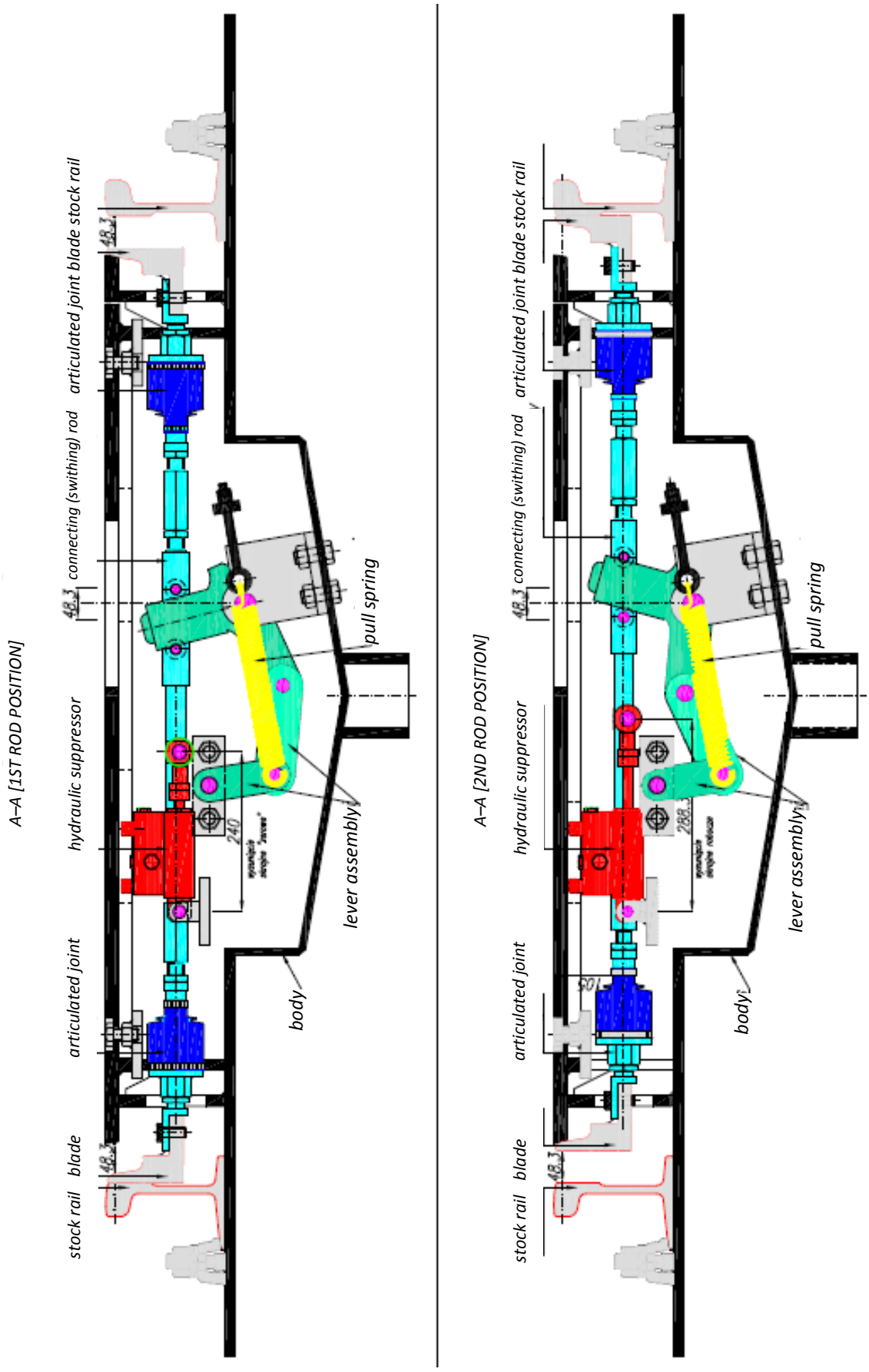


Figure 24. SZZT-1 spring lock of a tramway turnout

2.8 SZZT-2 spring lock of a tramway turnout

2.8.1 Technical data

Track gauge	1000 mm
Blade travel	36-60 mm
Joint of the control (connecting) rod	pin ϕ24
Pressure force of the spring mechanism	0.9-3.1kN
Torque at manual switching	150-450Nm
Allowed load acting on the cover of the box	12,000 kg
Weight of the cover	35kg
Total weight	ca. 220kg

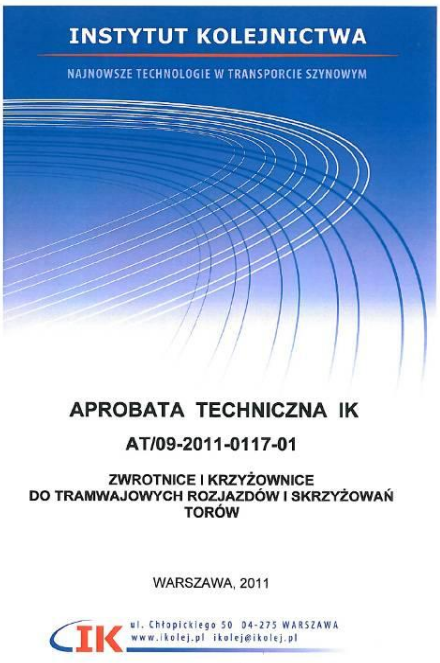
The SZZT-2 lock is designed for entry or exit switches with manual switching for the track gauge of 1000 mm. The structure of the box is made from metal plates 15 mm wide and is equipped with a drainage system in the lower section of the body. The cover is made from a metal plate 20 mm thick. The blades are moved in entry switches using a bar inserted through an opening in the cover into the control rod lever. The required force of switching and pressure is ensured by two spiral pull springs installed symmetrically on both sides of the control rod. Spring tensioners are used to adjust the spring pulling force. 2 turnbuckles mounted on both sides of the lever are provided to adjust the lengths of the rod segments. A hydraulic suppressor is applied in the lock to minimize the noise caused by blade closing. Installed in the exit switches, the lock meets the requirement for trailing movement.

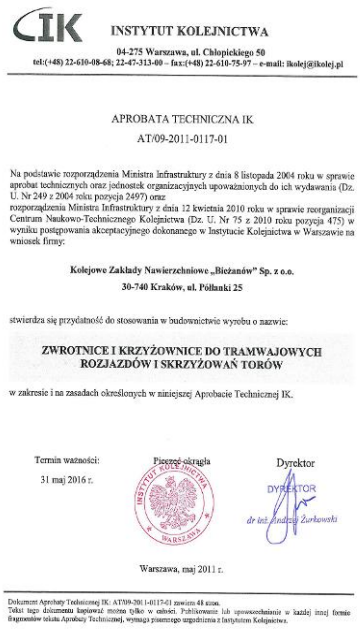
3 A list of applicable standards, statutory provisions and other normative documents

- Technical approval no. CNTK AT/09-2011-0117-01 Switches and frogs for tramway turnouts and track crossings
- Technical approval no. CNTK AT/09-2011-0118-01 Expansion joints and connection rails for permanent ways
- Technical guidelines for designing, construction and maintenance of tramway tracks, issued by the Ministries of Administration, Regional Economy and Environmental Protection, Department of Urban Transport and Roads, Warsaw 1983.
- PN-K-92011 "Tramway tracks – requirements and tests" 1998.
- PN EN14811 Tramway tracks and turnouts. Special purpose grooved rails and profiles, October 2006 Issued by the Polish Standardization Committee
- Technical Conditions WT/BS-/J.010 Supplies of tramway rails, MITTAL;3 February 2006
- Technical Conditions for the Completion and Acceptance of Railway Rails No. WTWiO-ILK3-5181-2/2004/EP dated 01 September 2004
- PN-EN 13674-1 Vignole railway rails 46 kg/m and above, 2003
  and PN-EN 13674-2 Profiles used in turnouts, April 2006
- PN-EN ISO6506-1 Brinell hardness test.
- EN ISO10003-1 Metallic materials. Hardness test according to Brinell, Test method.
- EN 10163-1:1991 Specification for delivery requirements for surface condition of hot rolled steel plates, wide flats and sections
- Technical Conditions for Permanent Way Maintenance on Railway Lines, Warsaw 2002 – Attachment to Resolution No. 155 of the Board of Directors of the Polish State Railways – Polish Railway Lines dated 6 June 2002
- ID5 (D7) Instructions for thermite welding of rails of 2005
- Internal instructions and process specifications.
- ISO-9001 Quality Management System. – Bureau Veritas Certification on 9 March 2007
- D-16 Instructions for flaw detection in rails and welds in tracks of the PKP network, dated 11 November 1996
- PN-EN 102004-204 Metallic products: Types of inspection documents
- Regulation by the Minister of Infrastructure dated 11 August 2004 on declarations of conformity of building materials Journal of Laws Dz. U. No. 198/2004 item 2041.
- PN-EN-22768-1:1990 (Table 1) Untoleranced dimensions
- Henryk Bałuch, Diagnostics of Railways, WKiŁ, Warsaw 1978
- Kazimierz Towpik, Maintenance of Railways, WKiŁ, Warsaw 1990
- Jan Kubalski, Tramways, WKiŁ, Warsaw 1978

4 Technical approvals

4.1 Technical approval no. CNTK AT/09-2011-0117-01 Switches and frogs for tramway turnouts and track crossings





4.2 Technical approval no. CNTK AT/09-2011-0118-01 Expansion joints and connection rails for permanent ways