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enabling green mobility

HIGH PERFORMANCE & MODERN TECHNOLOGY OF TURNOUTS FOR METRO

Laurent LETZELTER
August 27th 2025

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02 Vossloh References and Experience

03 Switches and Crossings basics

04 V-Met Range

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06 Proposal for Hanoi Metro

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01

PRODUCT LINE PRESENTATION

VOSSLOH SWITCH SYSTEMS

A COMPLETE RANGE FOR EVERY TYPE OF USE

Railways

In more than 85 countries

V-Net

Conventional Railway
V < 230 Km/h

1980
1st High-Speed turnout

V-Speed

High-Speed and Very High-Speed
up to 350km/h

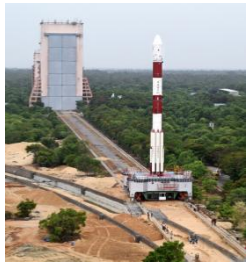
2007 Speed Record > 560 km/h

Up to 42 tons axle load

V-Freight

Heavy Traffic
> 25 tonnes

Up to 250 tons wheel load



Special tracks:
mines, ports, etc.

Urbains Transport

V-Tram

Tramways

V-Met

Metros

V-Met

VAL

UTS TRANSPORT TYPE CLASSIFICATION

THE PLACE OF METRO/MRT IN THE URBAN TRANSPORT SYSTEM WORLD

			Segregated level (%)	Trainset length (m)	Trainset capacity (passengers)	Line capacity (passage per hour in peak direction)	Commercial speed (km/h)	Distance between stations (m)
V-Tram	Tram		0	15-30	170-260	> 3 000	< 15	300-400
	LRT		1-99	20-50	200-530	3 000 11 000	15-30	300-500
V-Met	Metro MRT		100	40 150	48 2 300	10-80 000	25-40	800 1 500
V-Net	Commuter trains		100*	50 200	640 2 500	10-80 000	40-60	1 000 5 000
	Regional trains		100*	50 100	320 1 250	5-2 000	40-60	4 000 25 000

* Protected level crossings

Data : UITP

INTERNATIONAL STANDARDS FOR RAILWAYS

MAIN WORLDWIDE APPLICABLE STANDARDS

AREMA
AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION

CEN

VDV
VERBAND DEUTSCHER VERKEHRSUNTERNEHMEN
OR 14 – WEICHEN UND KREUZUNGEN

STANDARDS Australia

JIS

Gost Standard srl

UIC
INTERNATIONAL UNION OF RAILWAYS

VÖV UTP
Verband öffentlicher Verkehr
Union des transports publics
Unione dei trasporti pubblici

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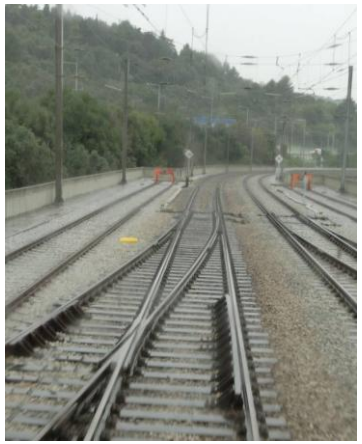
02

VOSSLOH REFERENCES AND EXPERIENCE

REFERENCES

TURNOUTS FOR METRO



More than 80 networks

V-Met

Bangkok
Brucellas
Cairo
Calcutta
Caracas
Delhi
Dubai
Hong Kong
Kaohsiung
Kuala Lumpur
Lisbon
London
Monterrey
Montreal
Mumbai
Oslo
Paris
Porto
Santa Clara
Santiago
Singapore
Stockholm
...

V-Met (Tyres)

Lyon
Paris
Lausanne
Marseille
Mexico
Montreal
Santiago

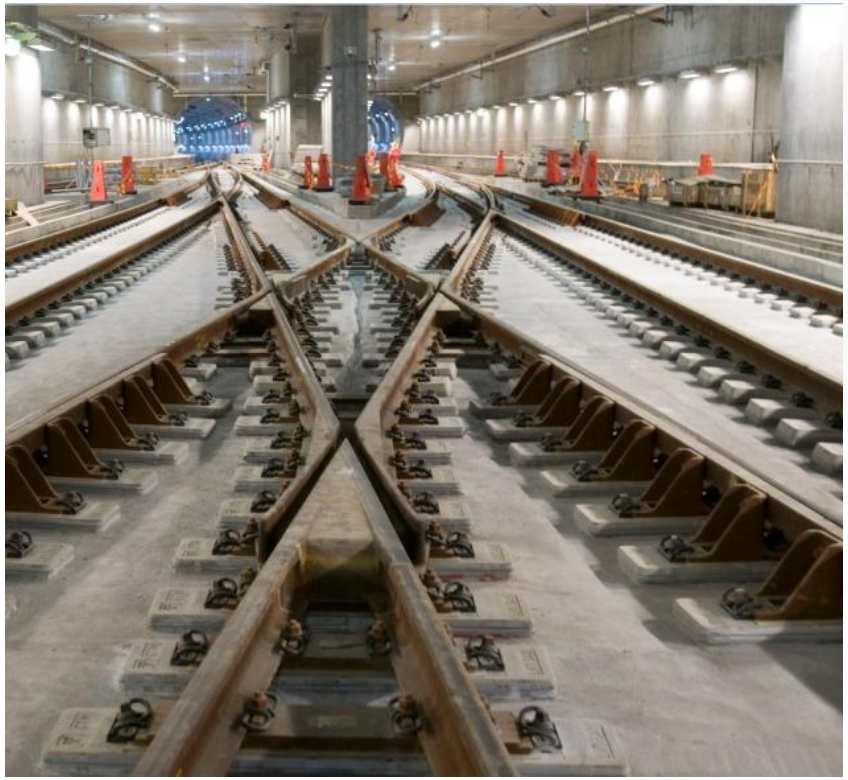
V-met (VAL)

Chicago
Jacksonville
Korea
Lille
Orly
Roissy
Rennes
Taipei
Turin
Toulouse

REFERENCES

V-MET

Bangkok
Brussels
Cairo
Calcutta
Caracas
Delhi
Dubai
Hong Kong
Kaohsiung
Kuala Lumpur
Lisbon
London
Monterrey
Montreal
Mumbai
Oslo
Paris
Porto
Santa Clara
Santiago
Singapore
Stockholm
...



REFERENCES

V-MET TYRES

Lyon
Paris
Lausanne
Marseille
Mexico
Montreal
Santiago

REFERENCES

V-MET VAL AND NEOVAL

Chicago
Corea
Jacksonville
Lille
Orly
Roissy
Rennes
Taipei
Turin
Toulouse

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03

SWITCHES & CROSSINGS BASICS

SWITCHES & CROSSINGS BASICS

TYPE OF TURNOUTS

Product family :

- Switch & Crossing (or S&C) → EN 13232-1

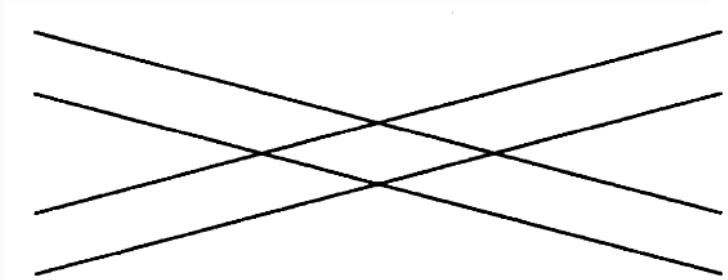
Other names :

- Special Trackwork
- Turnouts
- Switches
- …

Turnouts are devices that provide two main functions permitting tracks:

To separate → Diverging routes → Connection

To cross one another → Secant routes → Diamond crossing

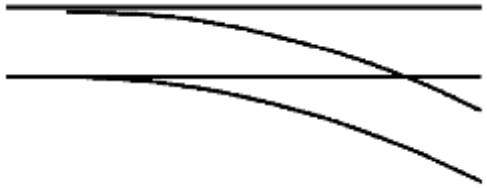


Using these two basic turnouts, it is possible to construct a full range of turnouts that permit several functions simultaneously

SWITCHES & CROSSINGS BASICS

TYPE OF TURNOUTS

2 Single Turnouts



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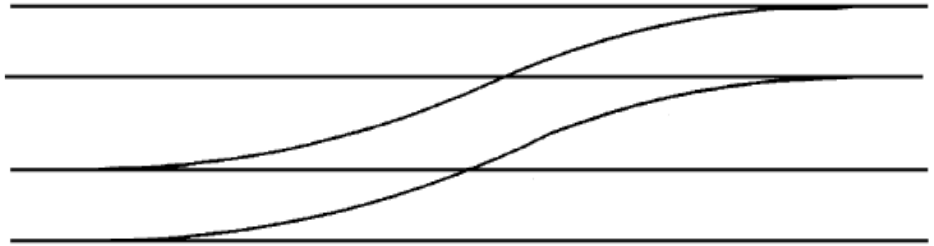
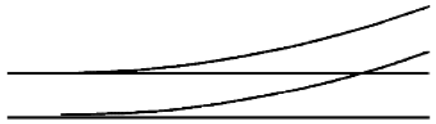
1 Single Crossover



Allowing two adjacent tracks to join each other

2 Single Turnouts (LH)



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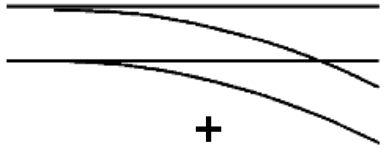
2 Single Turnouts (RH)



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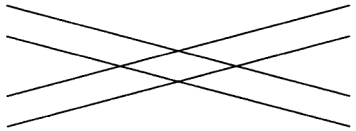
1 Diamond Crossover



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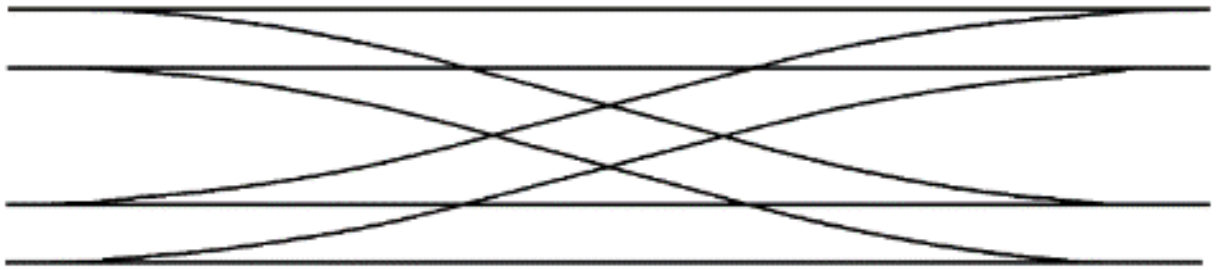
1 Scissors Crossover (Double Crossover)

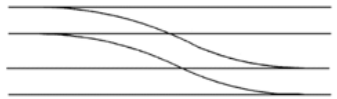
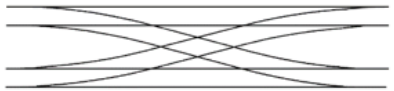
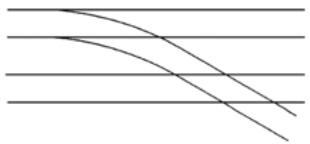
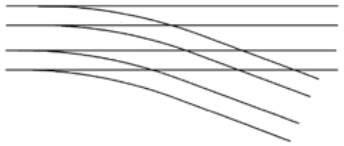


Allowing two adjacent tracks to join each other in both directions

SWITCHES & CROSSINGS BASICS

TYPE OF TURNOUTS

Turnout combinations

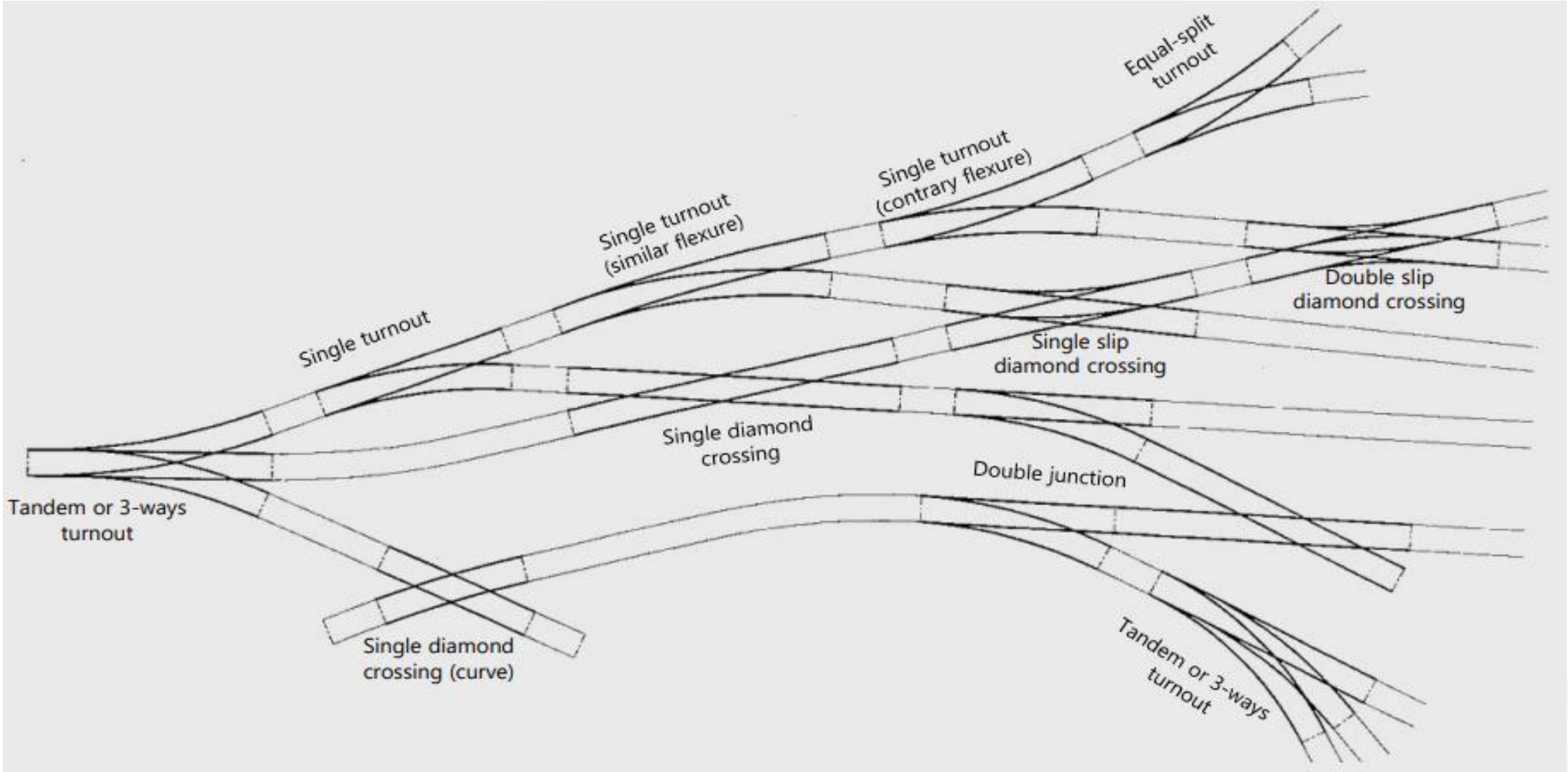
Turnout type	Abbreviations	Scheme
Single Turnout	ST	
Single Crossover	SC	
Scissors Crossovers/ Double Crossover	SCC	
Single Junction	SJ	
Double Junction	DJ	

Crossing Combination

Turnout type	Abbreviations	Scheme
Diamond Crossing	DC	
Single Slip	SS	
Double Slip	DS	

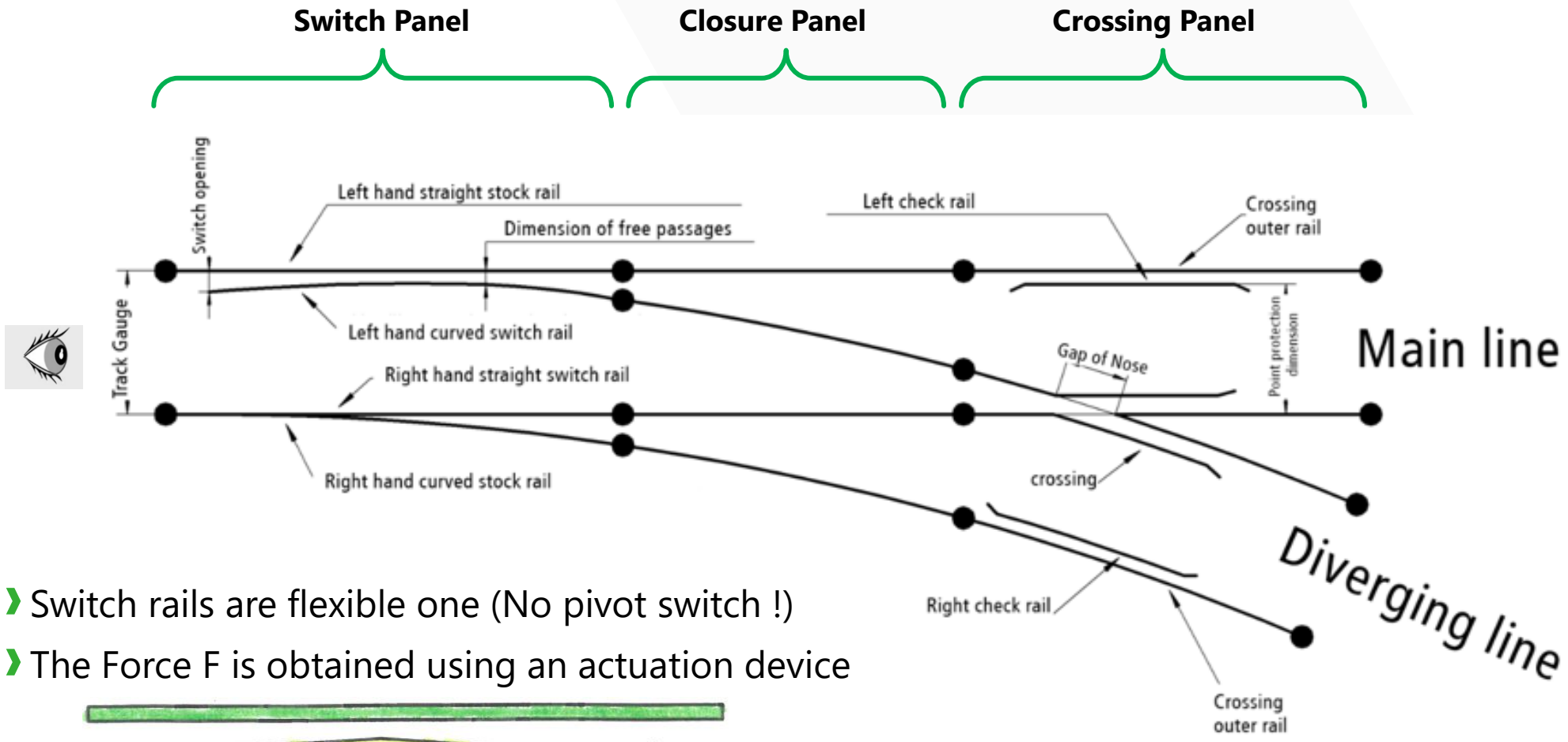
SWITCHES & CROSSINGS BASICS

TYPE OF TURNOUTS

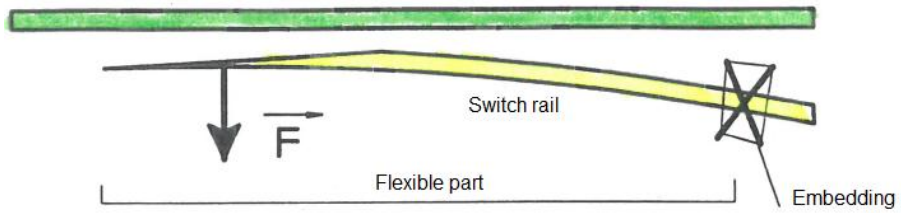


SWITCHES & CROSSINGS BASICS

TYPE OF TURNOUTS



- Switch rails are flexible one (No pivot switch !)
- The Force F is obtained using an actuation device

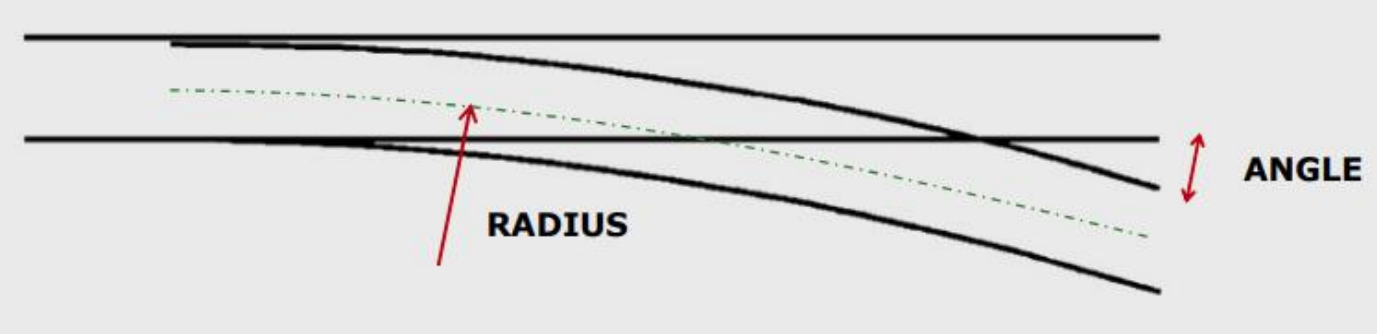


SWITCHES & CROSSINGS BASICS

GEOMETRIES

- Each turnout is defined by a radius and an angle
- The radius means the curve of the diverging line

  It can be a continuous curve, a compound curve or a transition curve witch rails are flexible one (No pivot switch !)
- The angle refers to the main directions between tracks at heel of turnout (at joints)



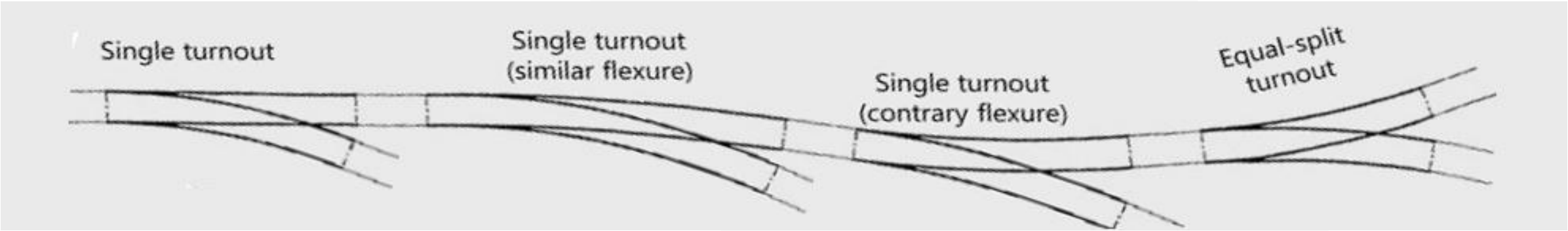
- It is more convenient to describe a turnout with the tangent of the angle than with the angle itself.

  For example :

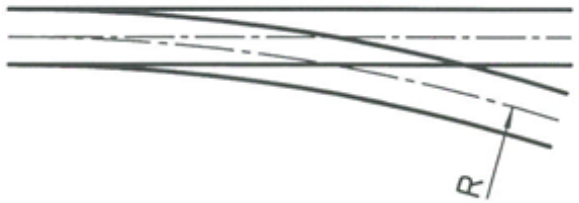
Tg.1/9 = 0,111111111 = 6,3401918°

SWITCHES & CROSSINGS BASICS

BENDED TURNOUTS



Straight Turnout



Contrary flexure turnout

$$R'1 = \frac{R' \times R}{R' - R}$$

Parameters of the radii :

- **R** = Diverging radius of the straight turnout
- **R'** = Main track radius of the bended turnout
- **R'1** = Diverging of the bended turnout (to calculate)

Similar flexure turnout

$$R'1 = \frac{R' \times R}{R' + R}$$

SWITCHES & CROSSINGS BASICS

DENOMINATION

SC - 60E1/60E1A5 - Tg.1/9 - R=190m - CL=4200 - RH

- Type of S&C
- Vignole Rail
- Switch Rail
- Tangent
- Radius
- Tracks distance
- Diverging

Radius and tangent are linked :

If the speed increases, the radius needs to increase and the tangent (and angle) will decrease

- R=25m-Tg.1/2,18 or 1/4
- R=50m-Tg.1/6

Tramway/LRT

- R=100m-Tg.1/6
- R=140m-Tg.1/6 or 1/7
- R=190m-Tg.1/7 or 1/9
- R=300m-Tg.1/9 or 1/12

Metro/MRT

- R=500m-Tg.1/12 or 1/14
- R=820m-Tg.1/15,3
- R=1 200m-Tg.1/18,5
- R=1 530m-Tg.1/21
- R=2 500m-Tg. 1/26,5 or 1/27,5

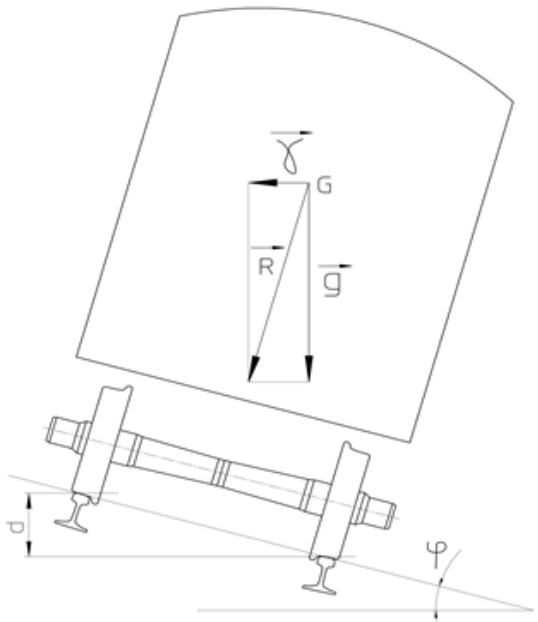
Conventional Railways

- R=3 000m-Tg.1/29
- R=3 500/CL-Tg.1/46
- R=7 500m-Tg.1/65

High Speed

SWITCHES & CROSSINGS BASICS

SPEED IN TURNOUTS



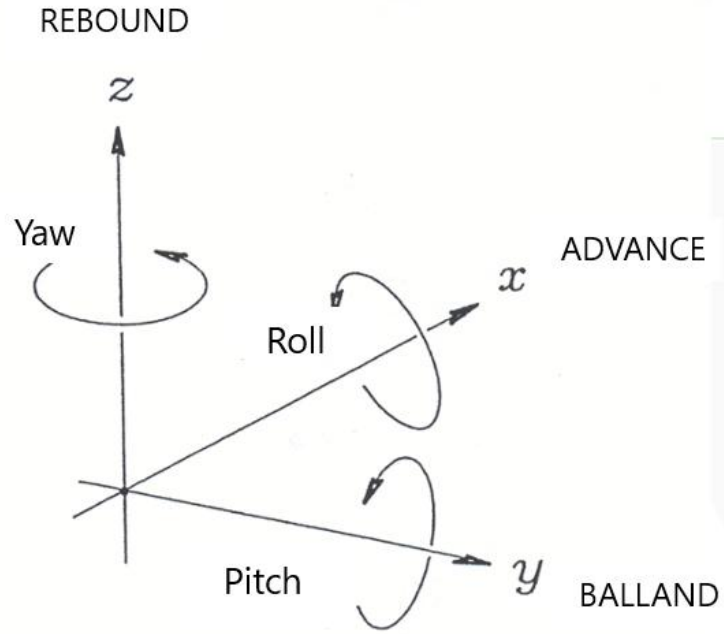
- The radius induces the speed limit in the track and the S&C
- The track can be laid with “cant” in curves to compensate the lateral acceleration
- S&C are laid without “can't”
  → The result is a cant deficiency
- The cant deficiency is the difference between the theoretical deficiency and the real deficiency in the track
- Formula : $d = 11{,}8\ V^2 / R \rightarrow V = \sqrt{Rd/11{,}8}$ V(Km/h) ; d(mm) ; R(m)
- Example for 1200m : $V = \sqrt{1200.100^*/11{,}8} = 100$ Km/h

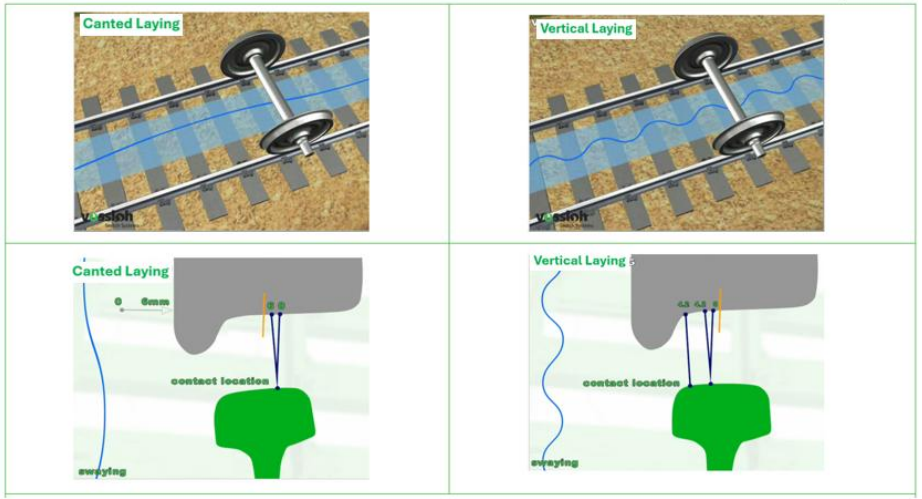
* 100mm is a compromise for the cant deficiency value coming from a maximal lateral acceleration of 0,654 m/s/s

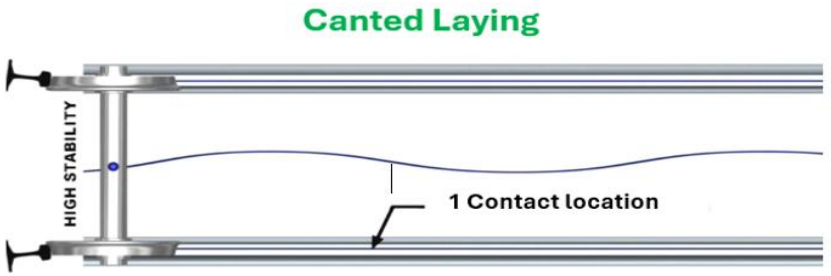
SWITCHES & CROSSINGS BASICS

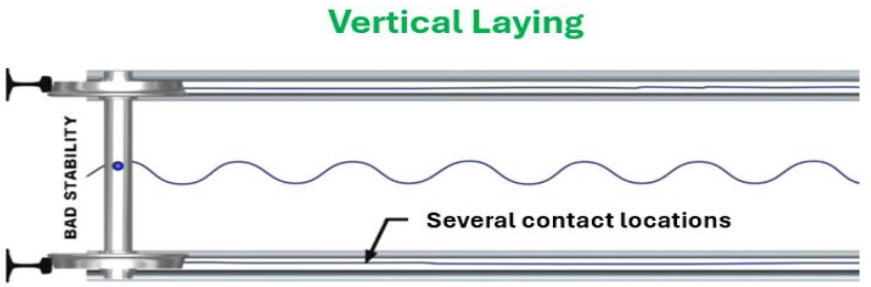
INCLINED TRACK LAYING

- Vehicle guidance









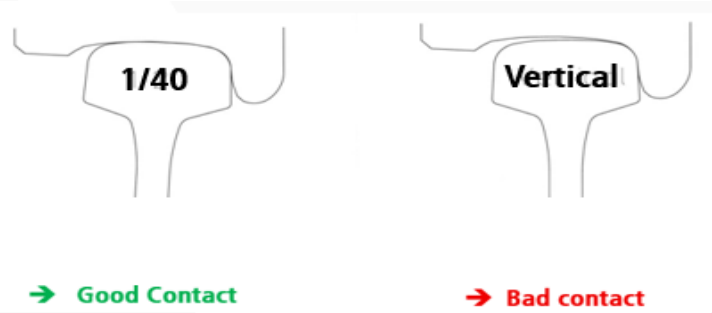
- Rail/Wheel contact is of capital importance for the movement of vehicles
- Numerous studies have been carried out to model the dynamic interactions existing between track and vehicle
- Necessity to determine the best compromise to optimize the position of the rail.
- The track is inclined of 1/40

SWITCHES & CROSSINGS BASICS

INCLINED TURNOUT LAYING

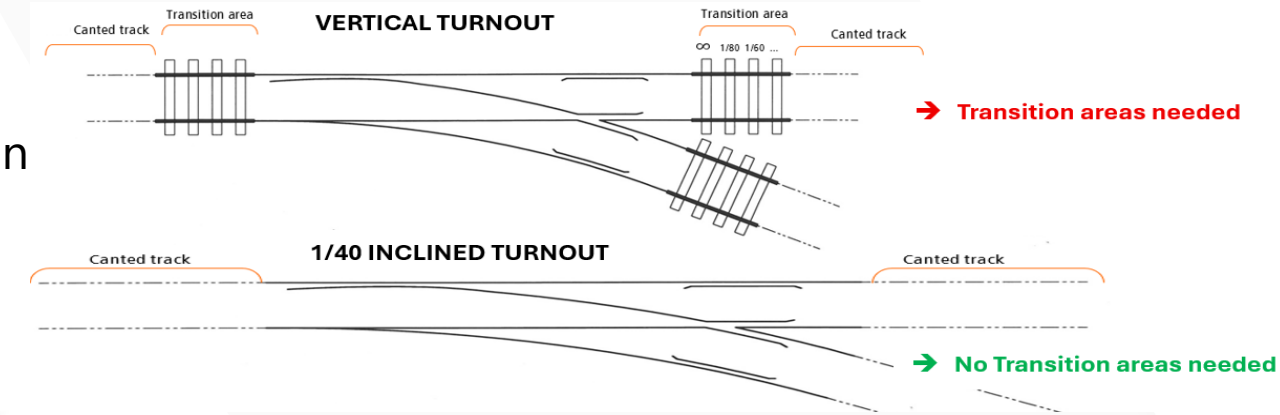
Worn wheel passage:

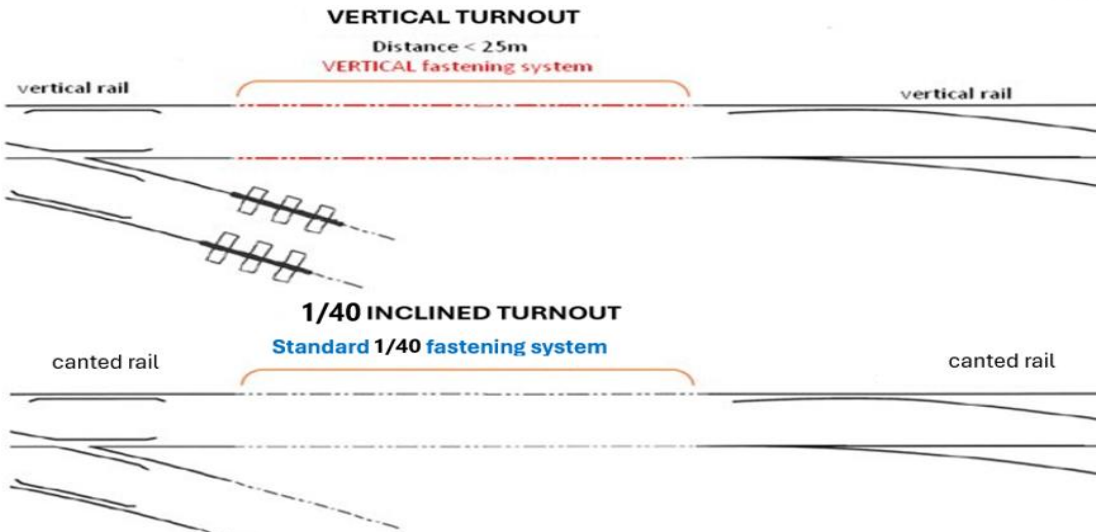
- The wheels roll almost exclusively on the 1/40 inclined current track
- If turnouts vertically laid, phenomena of rolling, yawing and pitching is increased



Transition areas needed:

- Special baseplates for gradual transition
- Risk of baseplate mixing during installation





Two close turnouts:

- Advisable to stick to a vertical installation in the connecting track section
- Special baseplates for flat laying must be used

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04

V-MET RANGE

A FULL RANGE OF TURNOUTS FOR METRO

2 FAMILIES OF PRODUCTS

V-Met

APPLICATION : 95%

- Turnouts for Metros using conventional railway technology
- Axle load up to 18 tons

V-Met Tyres

APPLICATION : 5%

- Turnouts for Metros on tyres
- VAL (Vehicle Automatic Light) turnouts for fully automated guided transport

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

FLEXIBILITY & PERFORMANCE

Vossloh designs and manufactures an increasingly innovative range of products that meet specific requirements and the constraints of urban infrastructures, while limiting investment and maintenance costs

Passenger comfort

- Inclined laying ➲ Optimum dynamic behavior
- Welded turnout and crossing ➲ No gap
- Adapted fastening system ➲ Particularly important for Slab Track

Capacity & Metro Frequency Increase

- System IBAV/Forged tongue ➲ Elastic fastening of the switches
- Switch Tip Optimization ➲ Tongue reinforcement
- Welded Monobloc Crossing ➲ Optimization of wheel passage

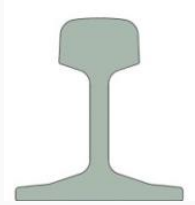
Technical Adaptation

- Adapted turnouts to meet specific geometrical constraints
- Laying types: on concrete bearers, slabs, synthetic and wooden sleepers
- Special characteristics linked to the various types of transport vehicle
- Rail profiles and steel grades

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

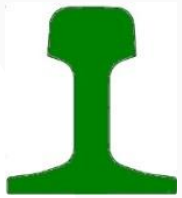
RAIL PROFILES AND STEEL GRADE

- **Vignole Rails**
  Profiles: 49E1 – 50E6 – 50E2 - 54E1 - 54E3 – 115RE — 60E1…
  Application: Stock Rails-Closure Rails-Crossing Extensions



- **Shallow depht Switch Rails**
  Profiles: 49E1A1 – 54E1A1 – 60E1A1 – 60E1A5 – 54E1A2…
  Application: Switch tongues

- **Symmetrical Switch Rails**
  Profiles: 50E1T – 50E2T1 – 60E6A1 – 54E1T1 – 60E1T2…
  Application: Switch tongues



- **Construction Rails**
  Profiles: 33C1 – 310C1…
  Application: Check Rails, Guard Rails, Crossings…

	Grade	Hardness HBW
Natural Hard Rails	R260	260-300
Heat Treated Rails	350HT	340-390

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

TYPES OF LAYING

Ballast Track

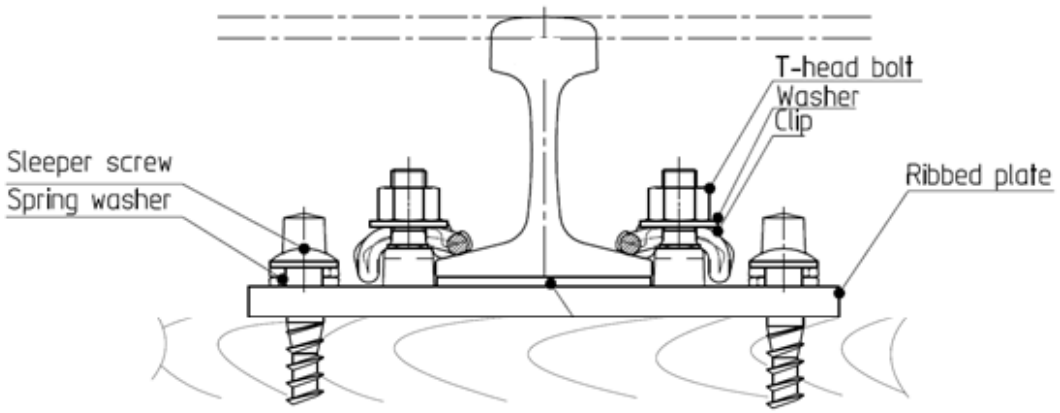
- Installation on timber sleepers, concrete bearers, steel or synthetic bearers
- Use in a ballast bed
- Tamping is required periodically to restore the original track parameters

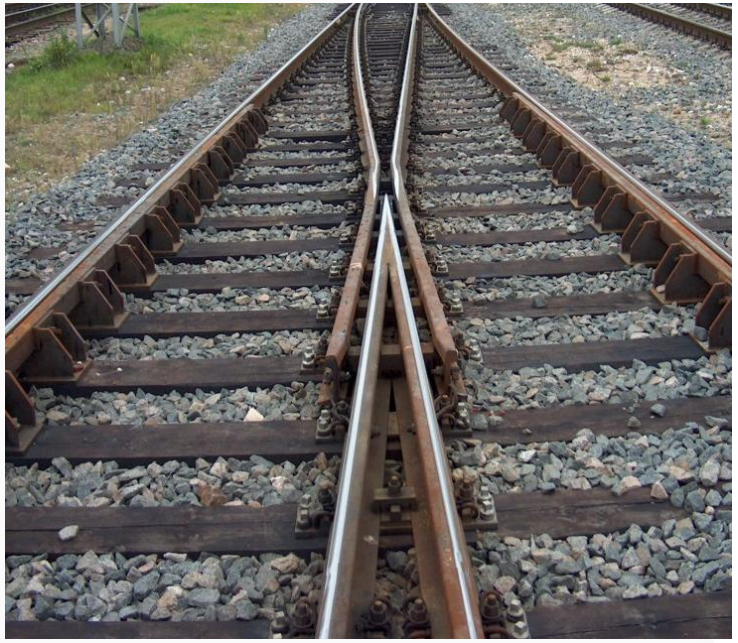
Slab Track

- The track elasticity is obtained by the fastening system
- Particularly suitable in tunnels
- Possibility of laying on concrete bearer (Booted or not)

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

BALLASTED TRACK : LAYING ON WOODEN SLEEPERS WITH BASEPLATES

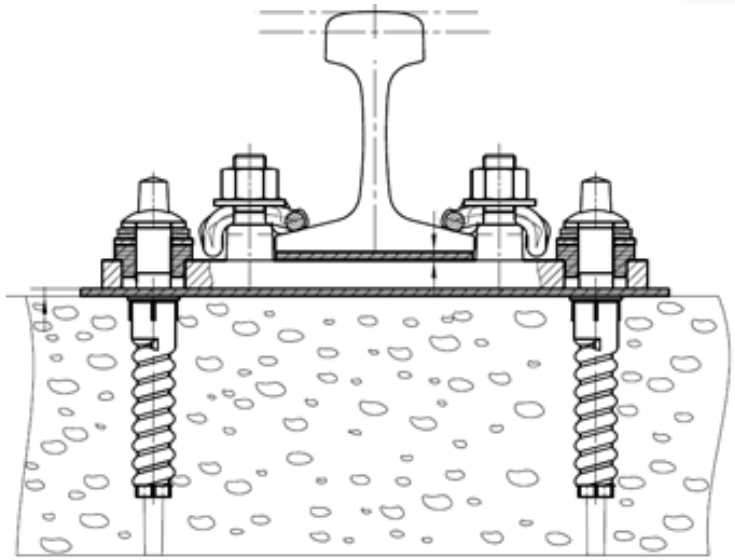


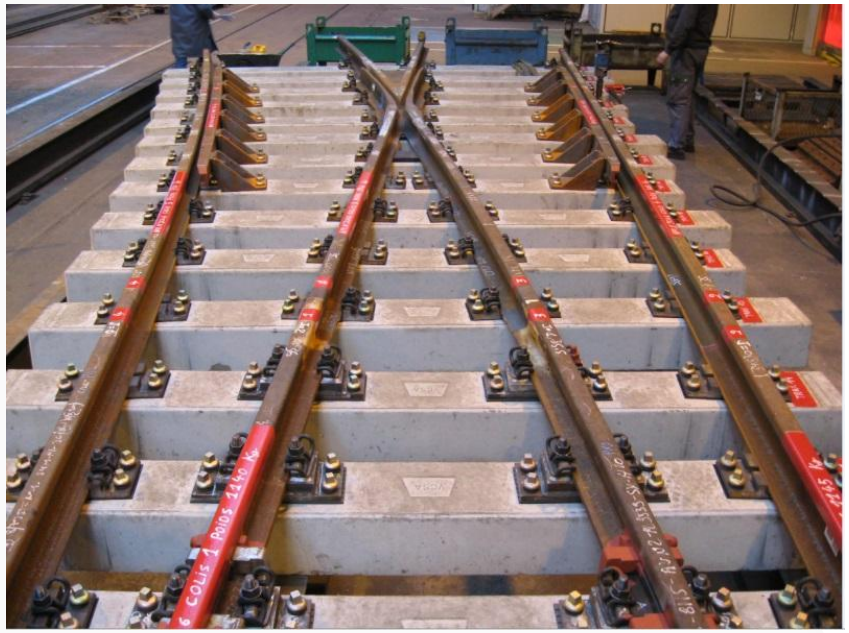


- Ribbed Baseplates made of rolled steel or spheroidal graphite cast iron
- Assembling of the baseplates onto the sleeper with 4 sleeper screws and spring washer
- Indirect rail fastening with 2 clip SKL and T-head bolts
- Rail pad placed over the baseplate

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

BALLASTED TRACK : LAYING ON CONCRETE BEARERS WITH BASEPLATES

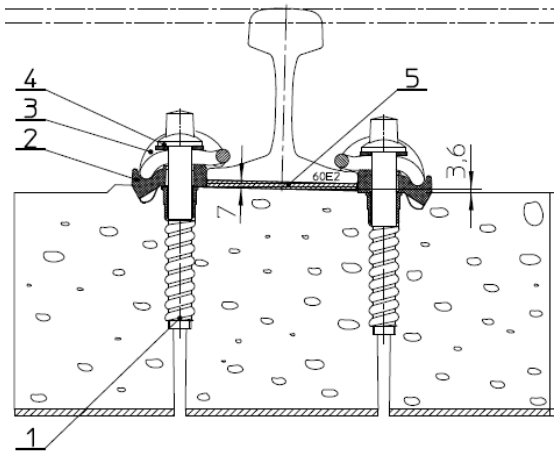


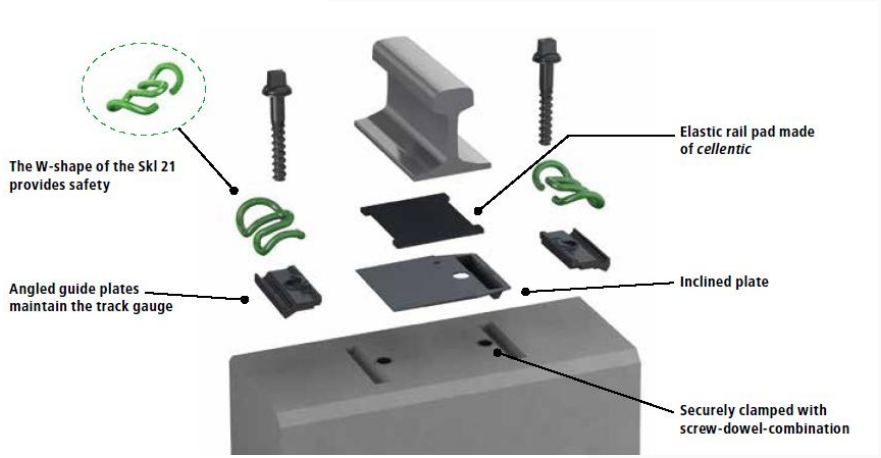


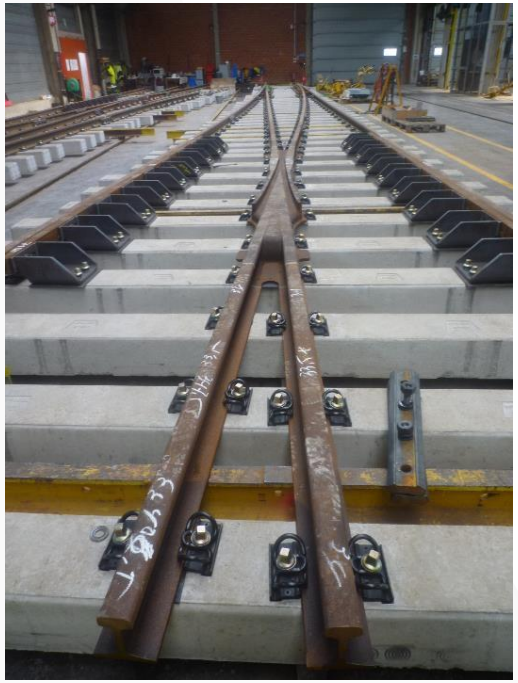
- Ribbed Baseplates made of rolled steel or spheroidal graphite cast iron
- Assembling of the baseplates onto the bearer with 4 sleeper screws, and elastic washer and insulated bushes
- Indirect rail fastening with 2 clip SKL and T-head bolts
- Rail pad placed over the baseplate
- Insulating pad places over the bearer

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

BALLASTED TRACK : LAYING ON CONCRETE BEARERS WITHOUT BASEPLATES WITH W21T SYSTEM



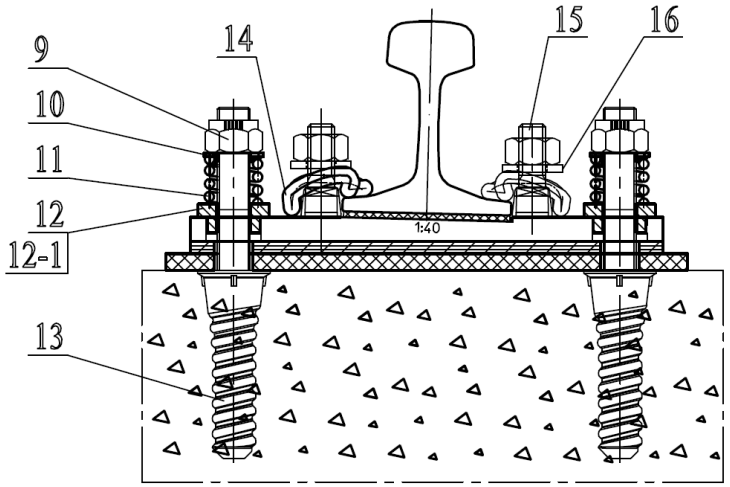


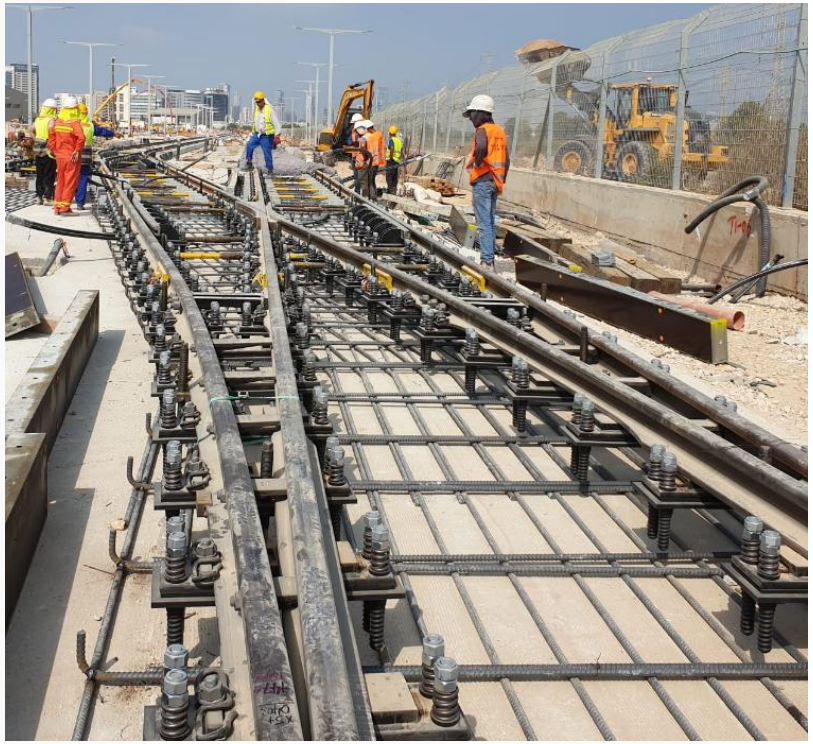


- The fastening system W21T optimizes the elasticity of the railway track with the help of an elastomer rail pad
- Contributes to the protection of the ballasted track bed
- Using highly elastic rail pads, the system W21T is suitable for Metro applications turnouts
- This fastening system does not require any ribbed baseplate
- Easy adjustment of the track gauge and vertical position

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

SLAB TRACK : LAYING WITH BASEPLATES



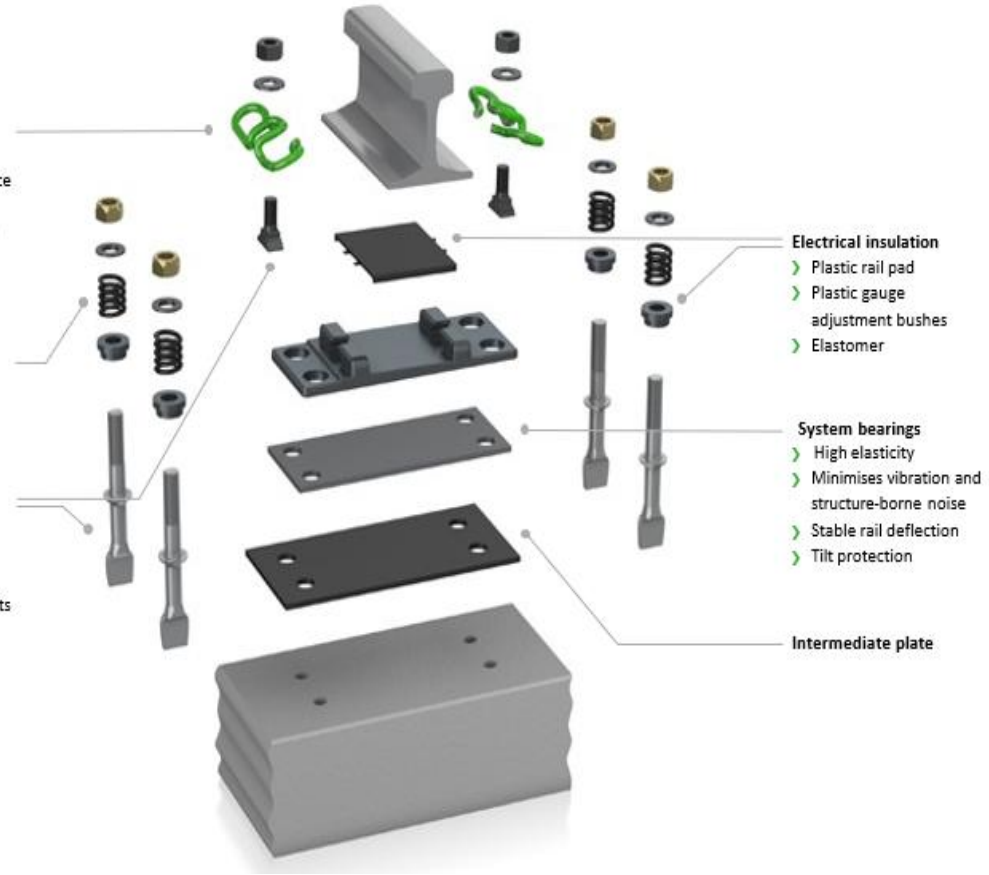


- Ribbed Baseplates made of rolled steel or spheroidal graphite cast iron
- A rail pad under the baseplate provides elasticity
- A rail pad on the concrete slab provides electrical insulation
- Fixing of the baseplates using anchoring bolts equipped with springs sembling of the baseplates onto the bearer with 4 sleeper screws, and elastic washer and insulated bushes
- Indirect rail fastening with 2 clip SKL and T-head bolts

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

SLAB TRACK : LAYING WITH BASEPLATES 1/2

Top Down



Skl 24
- Maximum safety
- Optimised rail creep resistance and tilt protection
- Resistant to dynamic vertical movements
- Maintenance-free system

Helical springs
- Minimal pretensioning of the elastomer

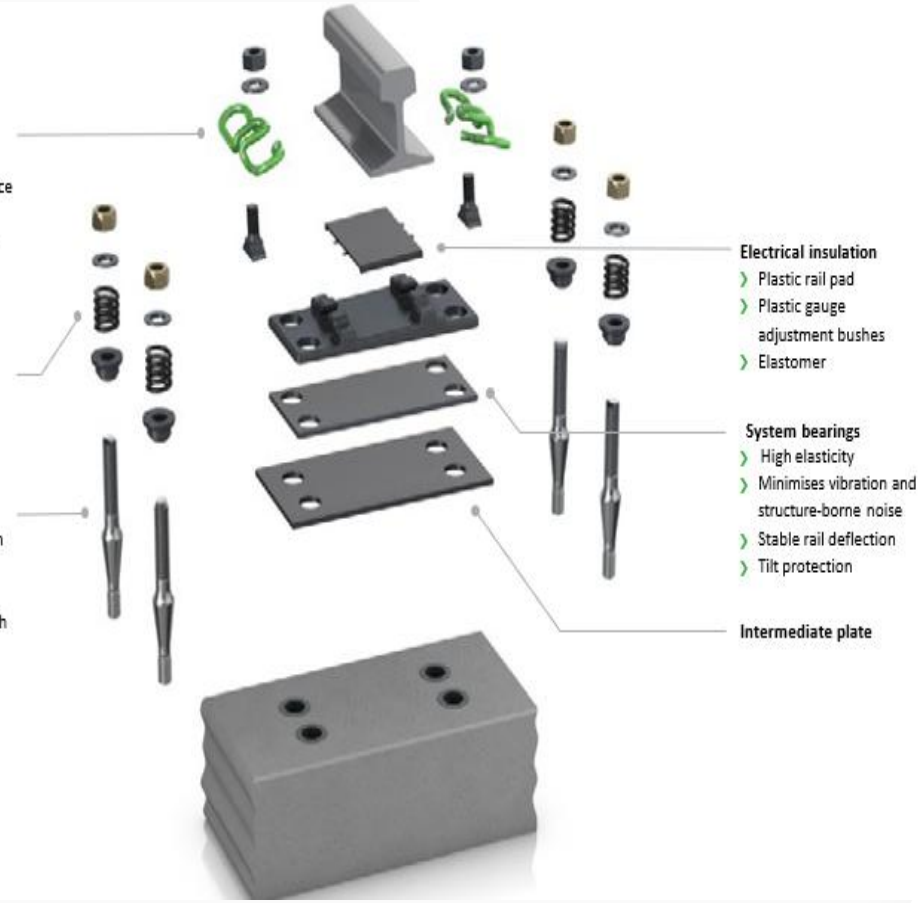
Safely tied
- Secure tensioning of the Skl to the ribbed base plate by means of T-headed bolts
- 4-hole fastener: 4 anchor bolts for ribbed base plate and concrete track

Electrical insulation
- Plastic rail pad
- Plastic gauge adjustment bushes
- Elastomer

System bearings
- High elasticity
- Minimises vibration and structure-borne noise
- Stable rail deflection
- Tilt protection

Intermediate plate

SD



Skl 24
- Maximum safety
- Optimised rail creep resistance and tilt protection
- Resistant to dynamic vertical movements
- Maintenance-free system

Helical springs
- Minimal pretensioning of the elastomer

Screw-dowel combination
- Secure tensioning with a high load capacity
- Cost-effective and resilient thanks to the use of high-tech materials

Electrical insulation
- Plastic rail pad
- Plastic gauge adjustment bushes
- Elastomer

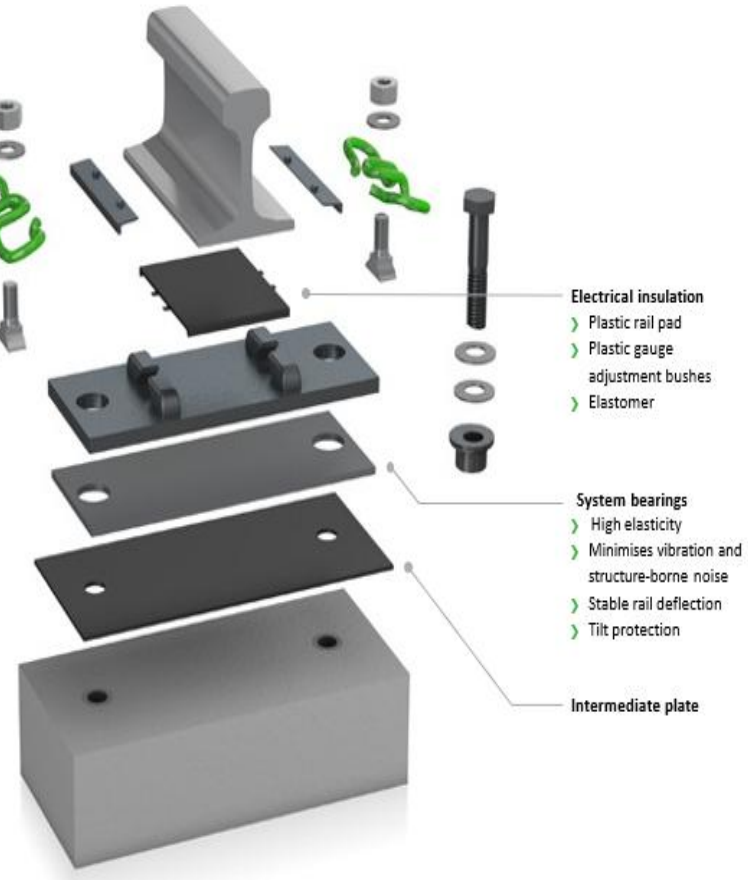
System bearings
- High elasticity
- Minimises vibration and structure-borne noise
- Stable rail deflection
- Tilt protection

Intermediate plate

SOLUTIONS TO MEET CONVENTIONAL RAIL SYSTEMS

SLAB TRACK : LAYING WITH BASEPLATES

Duo



Skl 24
- Maximum safety
- Optimised rail creep resistance and tilt protection
- Resistant to dynamic vertical movements
- Maintenance-free system

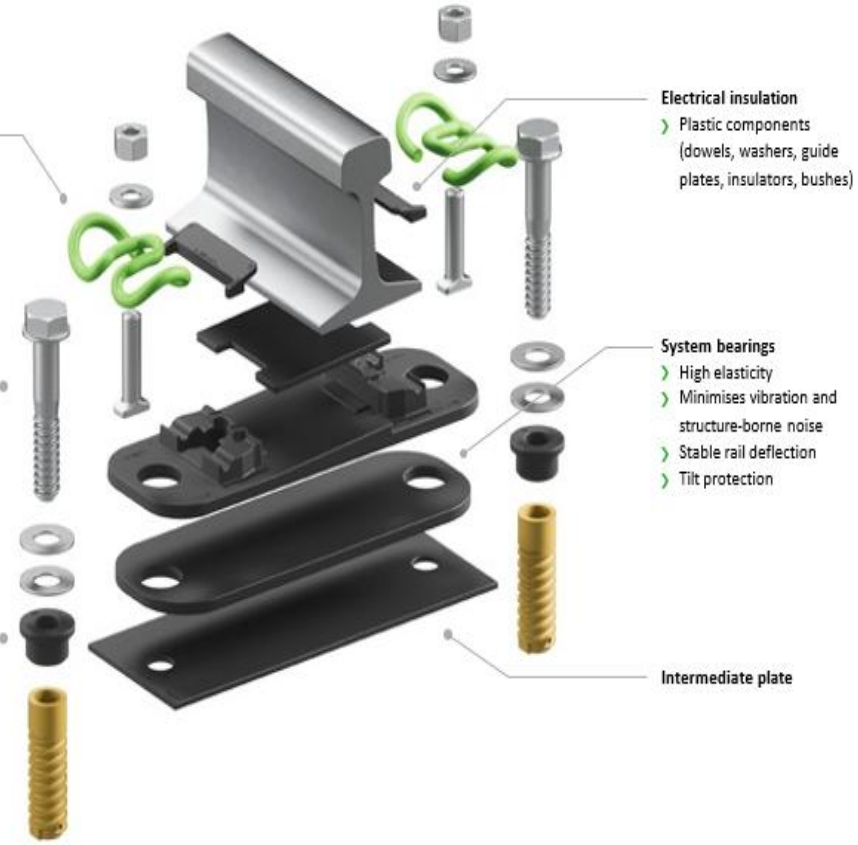
Fastener
- Tension clamp securely screwed to ribbed base plate using T-head bolts
- Hex bolts for ribbed plate and concrete superstructure

Electrical insulation
- Plastic rail pad
- Plastic gauge adjustment bushes
- Elastomer

System bearings
- High elasticity
- Minimises vibration and structure-borne noise
- Stable rail deflection
- Tilt protection

Intermediate plate

V



Skl 21
- Maximum safety
- Optimised rail creep resistance and tilt protection
- Resistant to dynamic vertical movements
- Maintenance-free system

Fastener
- Tension clamp securely screwed to ribbed base plate using T-head bolt
- Saves materials: Only two hex bolts and two plastic dowels required

Gauge adjustment
- Insulating brackets on the tension clamp
- Low pre-load of the elastic element
- Very low dynamic stiffness and no loss of elasticity

Electrical insulation
- Plastic components (dowels, washers, guide plates, insulators, bushes)

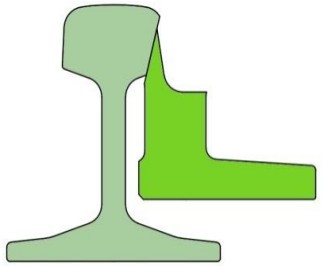
System bearings
- High elasticity
- Minimises vibration and structure-borne noise
- Stable rail deflection
- Tilt protection

Intermediate plate

V-MET RANGE

2 TYPE OF SWITCH DESIGNS

Asymmetrical Switch Rail with Forged Heel (Low / shallow Switch Rail)

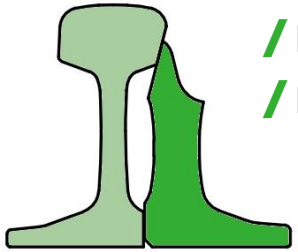


- Elastic laying with IBAV system
- Excellent horizontal inertia
  - ➲ Easy to get minimum flangeway

- Robustness of the embedding
- Machining of the stock rail foot avoided
- Better seating of the assembly

PREMIUM ➲ TR-260A

Symmetrical Switch Rail with Machined Heel (High Switch Rail)



- Rigid Laying
- Low horizontal inertia
  - ➲ More difficult to get minimum flangeway

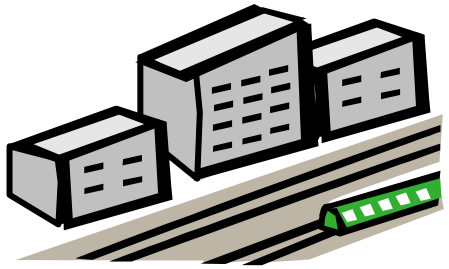
- Machining of the stock rail foot cannot be avoided
- Good vertical inertia

ECO ➲TR-260S

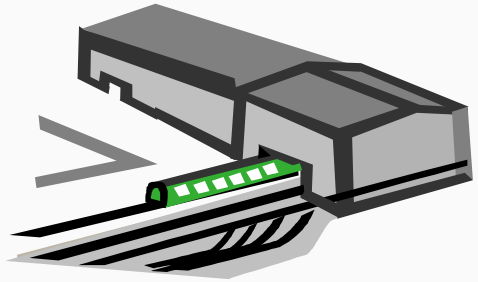
V-MET RANGE

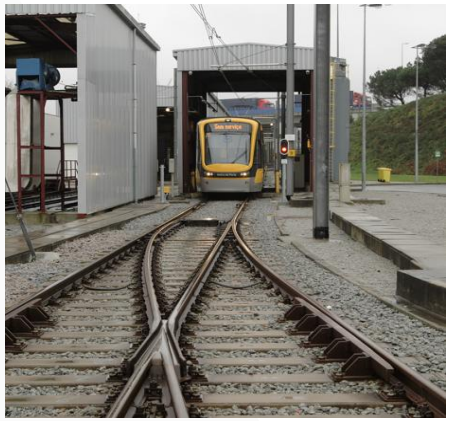
2 TYPE OF SWITCH DESIGNS

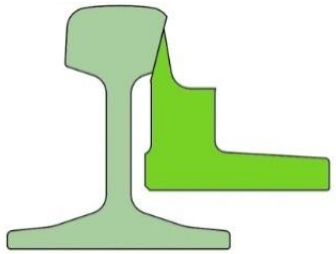
Mainline



Depot





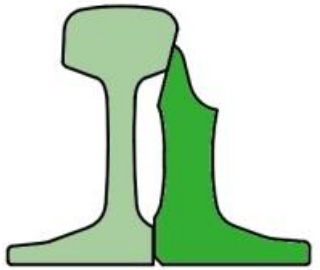


PREMIUM ➲ TR-350A

The best technical choice for a high-end product

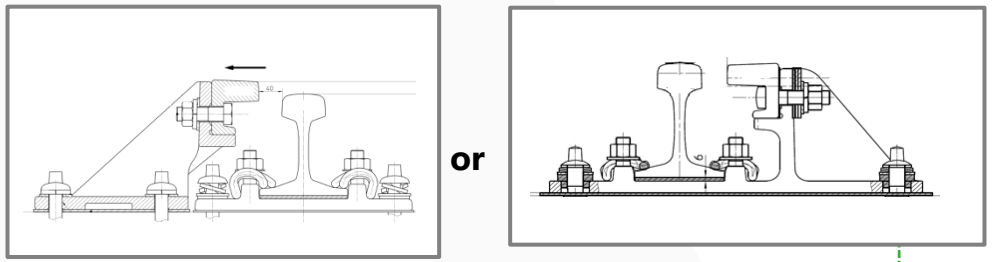
ECO ➲ TR-260S

The economical solution for a quality product



V-MET RANGE

2 TYPE OF SWITCH DESIGNS

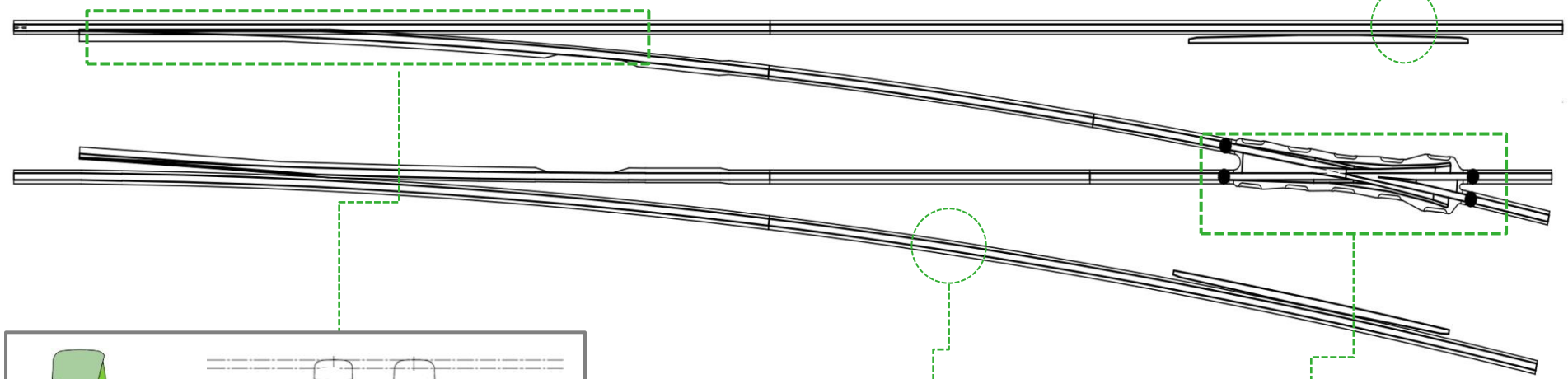


or

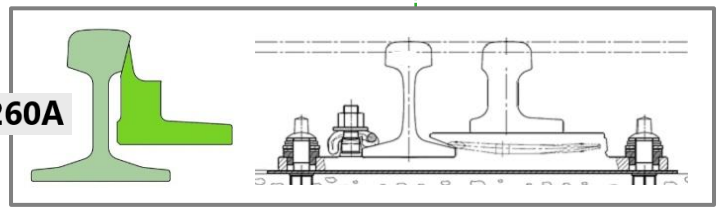
Switch

Intermediate Part

Crossing Part

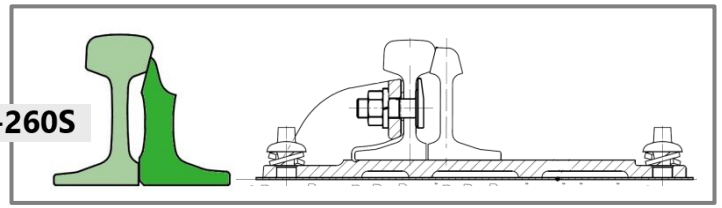


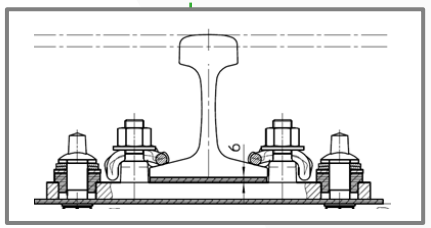
PREMIUM ➲ TR-260A



or

ECO ➲ TR-260S

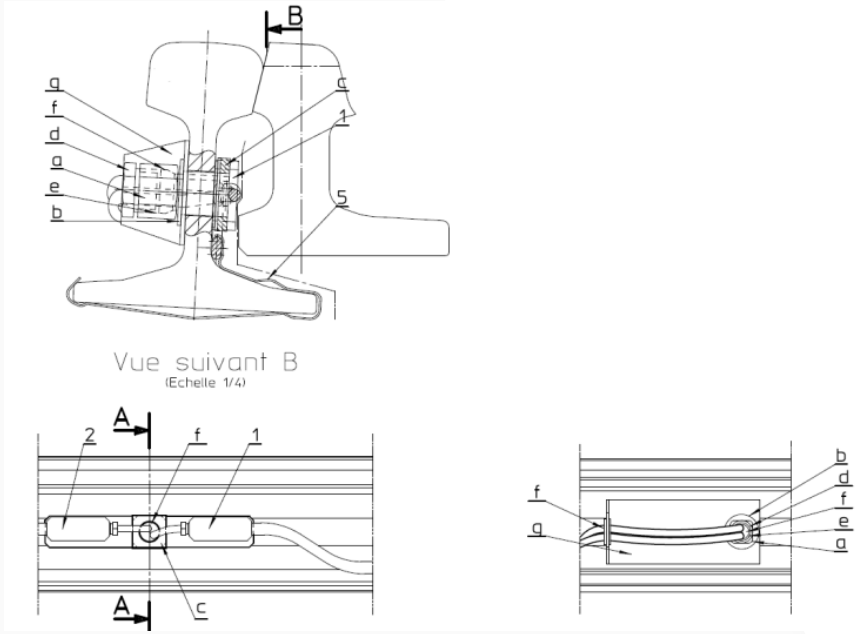




or

V-MET RANGE

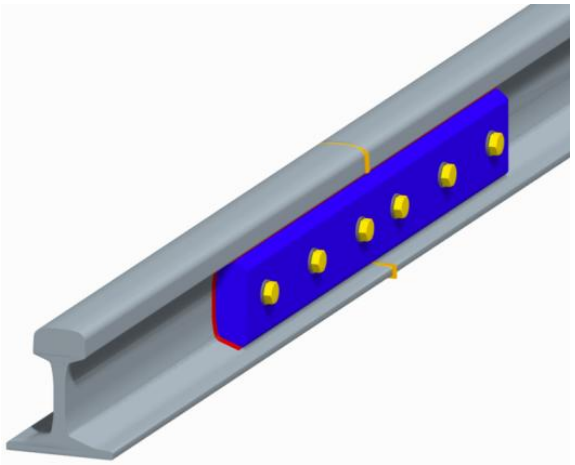
HEATING DEVICE

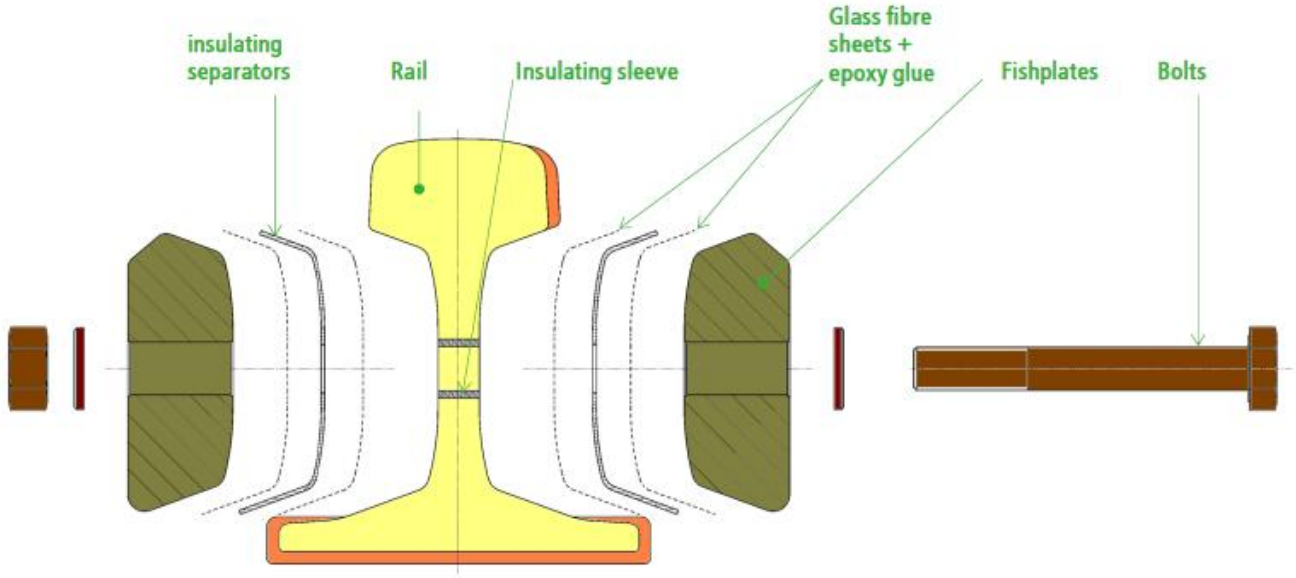


- The heating of each half switch is made electrically by linear heating elements.
- The tension of these elements is 220V or 115V according to the availability of the network.
- Linear heating elements are fitted along the inner side of the foot of the stock rail with elastic clips.
- These elements have a sealed connector on one extremity with the power wires.
- The quantity of the elements depends on the length of the flexible part of the tongue.

V-MET RANGE

GLUED INSULATING JOINT (GIJ)





- On special request, GIJs are integrated into the main track or the diverging track.
- The GIJs are made with 6-bolt steel bolts.
- These elements are insulated from the rail ends by insulating components

vossloh
enabling green mobility

05

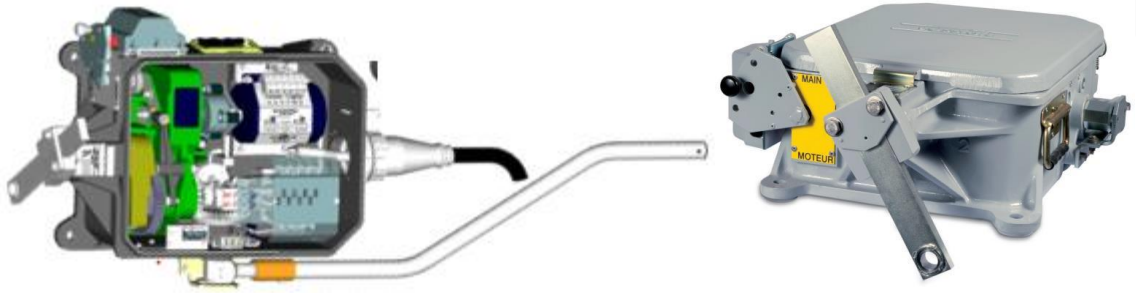
SIGNALING & SAFETY

SIGNALING & SAFETY

ALD → ACTUATION, LOCKING AND DETECTION

Actuation:

- The actuation includes the devices that allow the movement of the mobile elements in a turnout.
- The moving parts are the tongues and the and the points of the crossings with movable point.
- This actuation is performed by point machines (motors), in some cases, by manual hand lever boxes.
- There are a wide range of point motors at Vossloh: Electromechanical motors, Electrohydraulic motors, whether locked or trailable.
- The choice of the actuation device is made based on network safety rules, system operability (rolling stock), and signaling systems.



Point Machine MCEM91 :

→ Electromechanical

Point Machine MCEM91-T :

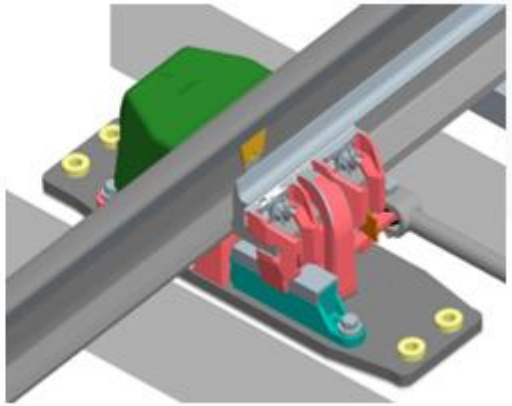
→ Electromechanical

SIGNALING & SAFETY

ALD → ACTUATION, LOCKING AND DETECTION

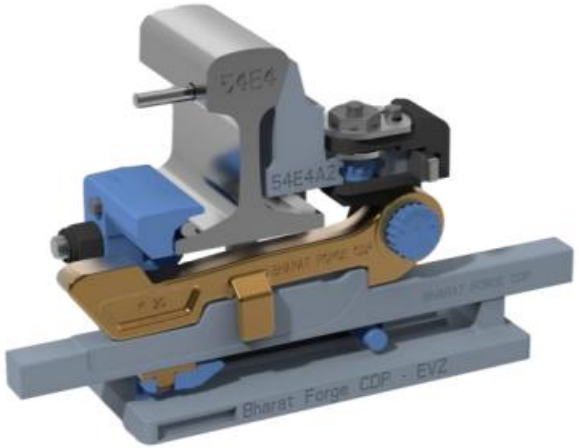
Locking:

- The purpose of locking is to secure the moving parts of a turnout in their end position.
- This device is driven by the operating system, which moves it into its final position.
- There is a difference between a “locked” system and a “clamped” system : locked system is not trailable, while in some cases and under certain conditions a clamped system is.



Locked System VCC :

→ Not Trailable



Clamped System EVZ :

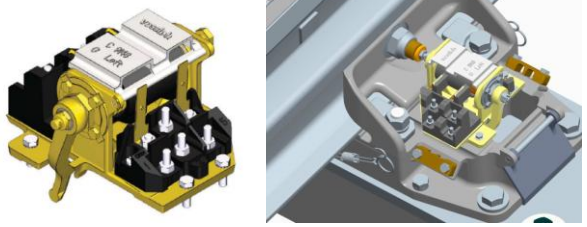
→ Trailable (Under conditions)

SIGNALING & SAFETY

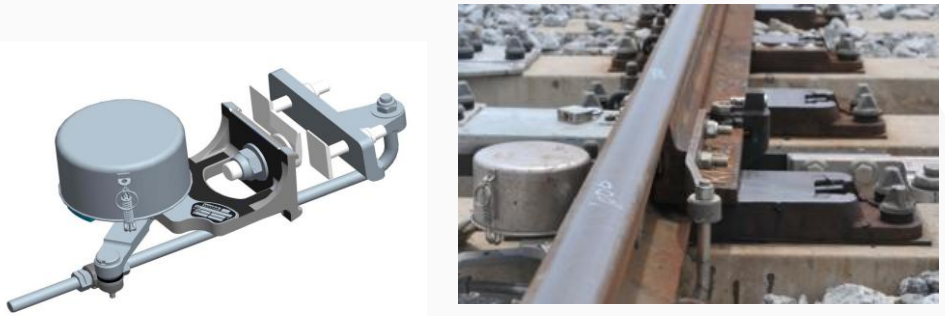
ALD → ACTUATION, LOCKING AND DETECTION

Detection:

- The detection device purpose is to verify the correct positioning of the moving parts, but also in some cases to confirm that the locking mechanism is active.
- This system enables obstacle detection in compliance with European standards and the operators internal regulations.
- For its high-end version, Vossloh offers a system housed directly in the locking mechanism frame that verifies the positioning of the tongues or the moving point of a swing nose crossing, as well as the locking mechanism.
- Additional controllers between the drives or at the point, provide the same function through the application of a driven controller which is attached to the fixed part. The moving part of the equipment is connected to the controller by a driven connecting rod.



KV detector



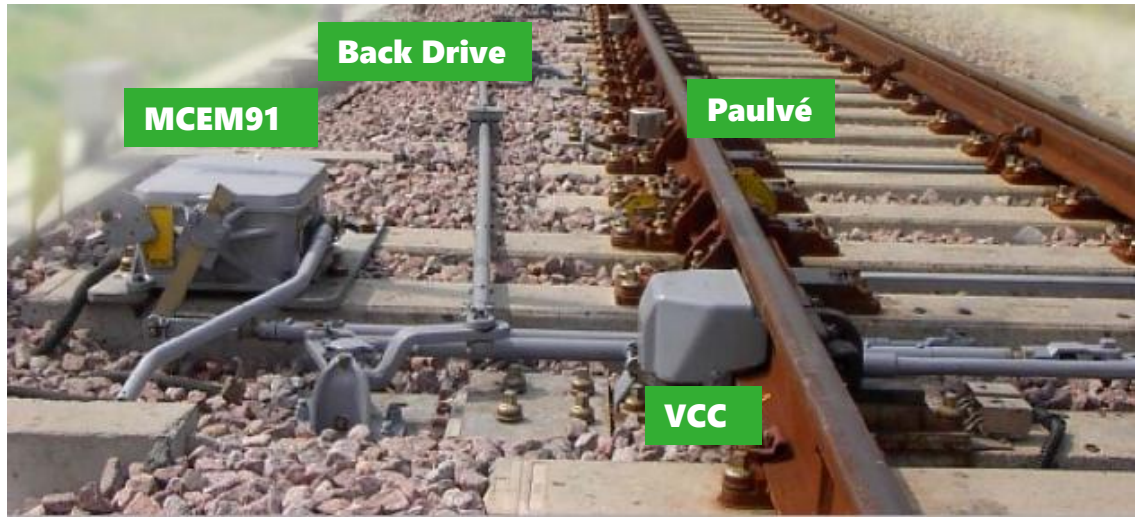
Paulve type detector

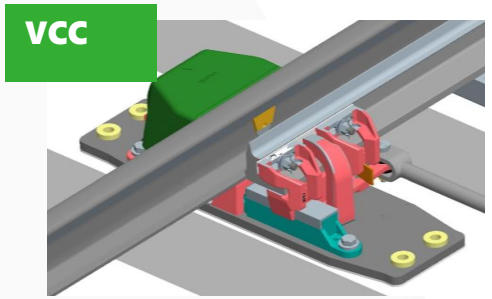
SIGNALING & SAFETY

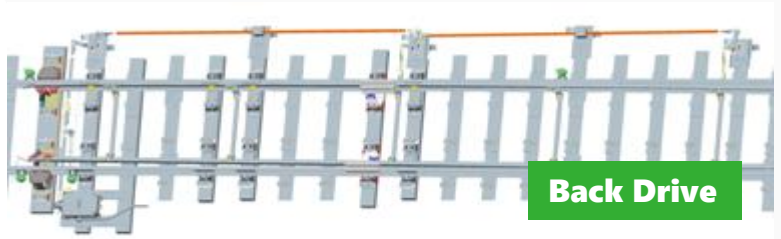
ALD IN THE TURNOUTS

The turnout that handles the guidance of the high speed must be locked and driven to allow the train to pass in complete safety

- The application together with VCC Locking system, and MCEM 91 Point Machine is the
  - widespreated in Europe
  - has the advantage of locking the roding device
- "PAULVE" detectors complete this arrangement.
  These are assembled on the turnout, and their purpose is to validate the correct position of the moving elements.
- SIL 4 safety level

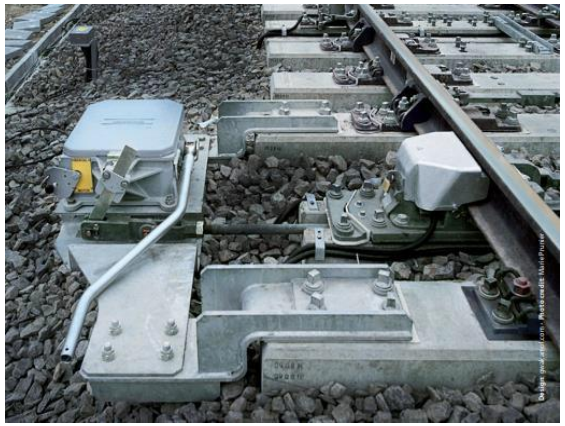


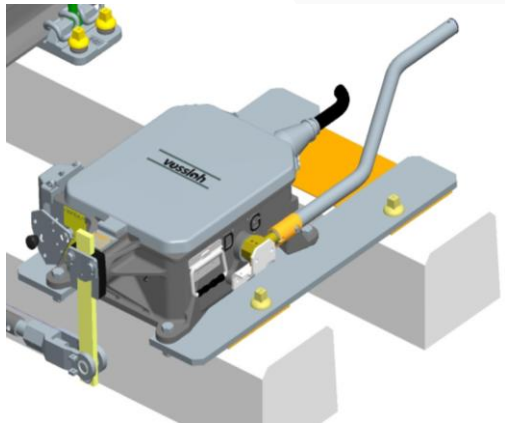


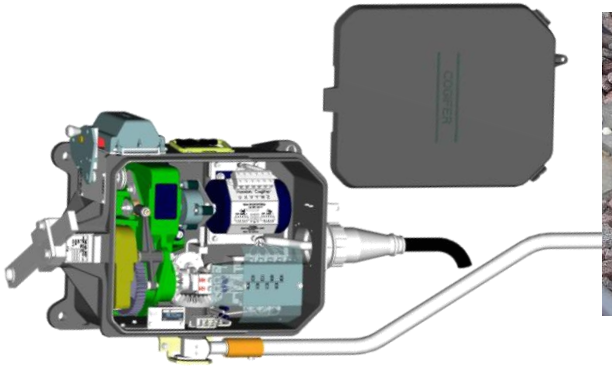


SIGNALING & SAFETY

POINT MACHINE MCEM91

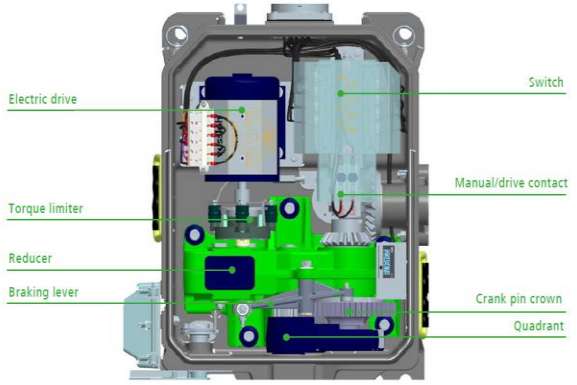


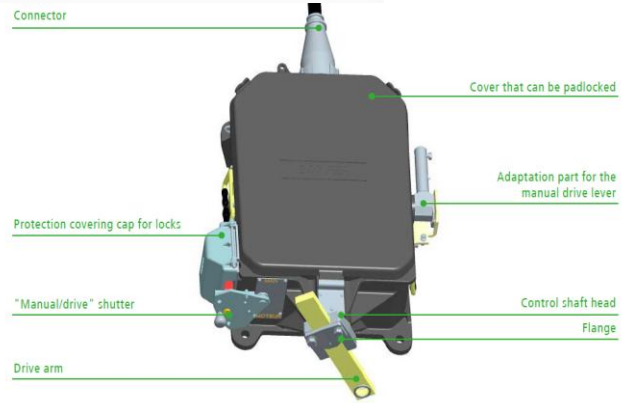




DESCRIPTION

- The electromechanical point machine provides the electrical drive of the switch, its locking, and detection in end positions.
- Compatible with concrete bearers, metal sleepers, concrete slab track…
- Stroke can be adjusted simply by moving the driving arm, slip is adjustable
- Reduced maintenance, one inspection per year only
- Due to its pendular movement, the throw is given by the driving arm length. While throwing, the point machine driving arm moves on a 60° angle with locking in end positions.
- Quick and easy in track replacement : 2 persons without handling equipment



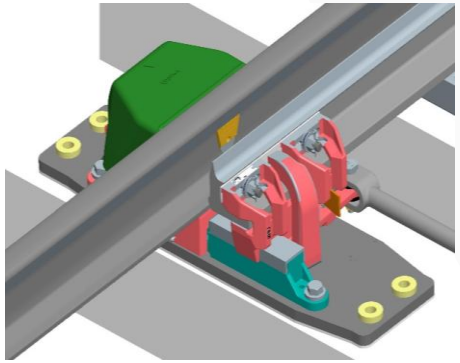


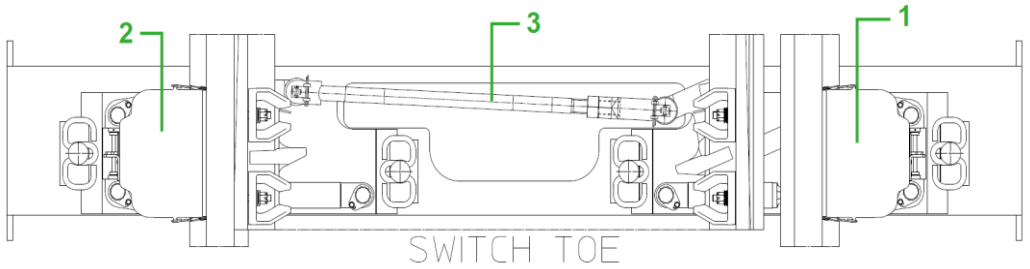
ADVANTAGES

- Economic solution, one point machine for the single back drive
- Approved by reference networks Applied in 6 VHS Networks
- Experience : 40 Years

SIGNALING & SAFETY

VCC SWITCH LOCKING DEVICE



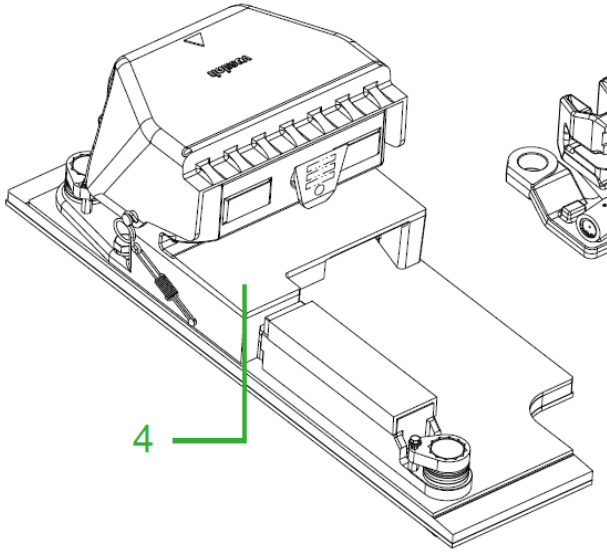


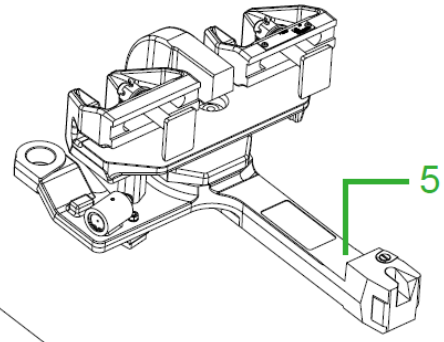
ADVANTAGES

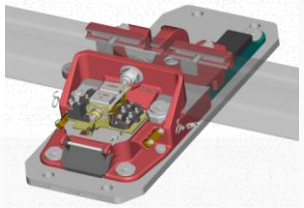
- Unique Vossloh Solution
- Excellent safety record
- No lubrification
- Applied in 12 VHS Networks
- Experience : 45 Years

DESCRIPTION

- Direct locking of the closed tongue and clamping of the opened one
- Stabilization system to prevent any movement
- Point and locking detectors housed in the frame

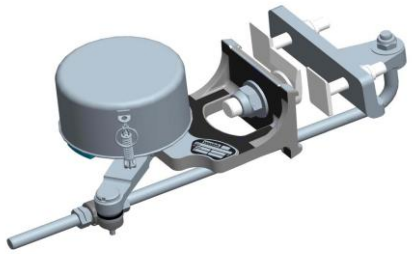






SIGNALING & SAFETY

PAULVE DETECTOR

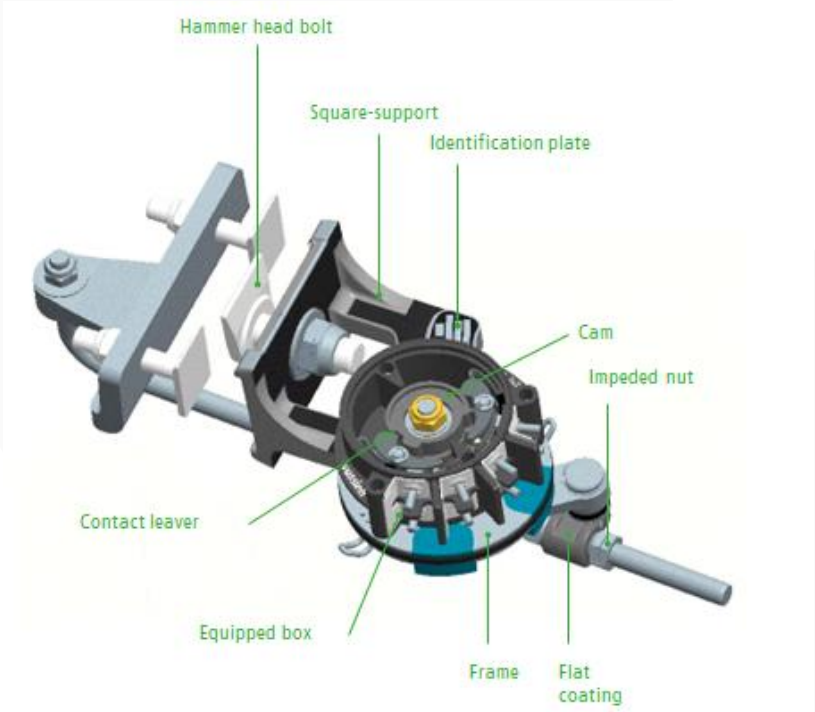


ADVANTAGES

- Driven detector: the moving element (tongue or swing nose) drives a detection mechanism, direct control (relative detection
- Low sensitivity to vibrations, to whether conditions
- Easy to install & Maintenance-free system
- Applied in 12 VHS Networks
- Experience : 40 Years

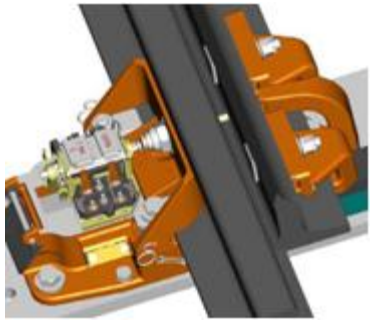
DESCRIPTION

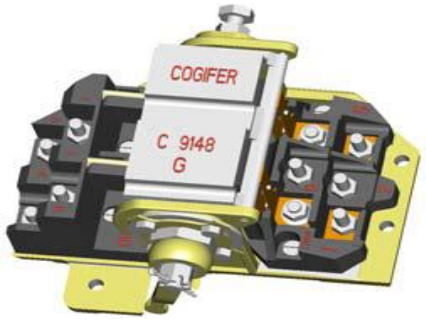
- Paulvé detector the position are placed in the flexible part of the tongue or the swing nose
- Paulvé detector perform the obstacle detection
- Usually assembled in pairs, even for the swing nose

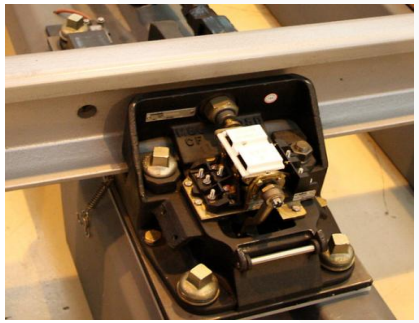


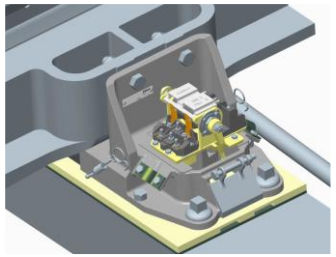
SIGNALING & SAFETY

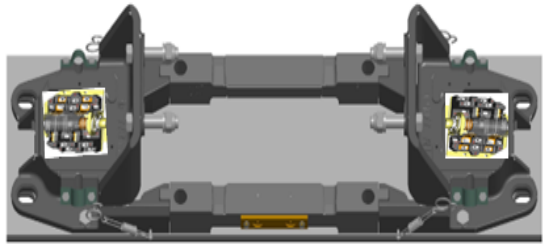
KV DETECTOR





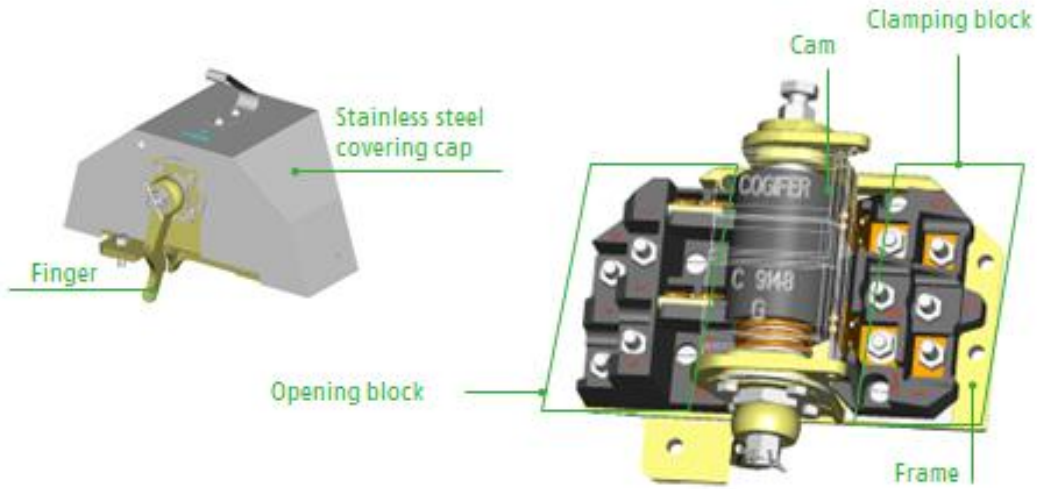






DESCRIPTION

- KV detectors are applied to check the position of the movable parts (tongue or swing nose) and if the locking is realized
- KV are housed by pair inside of the VCC frame (one in each VCC) and VPM frame (one in each side of the VPM)

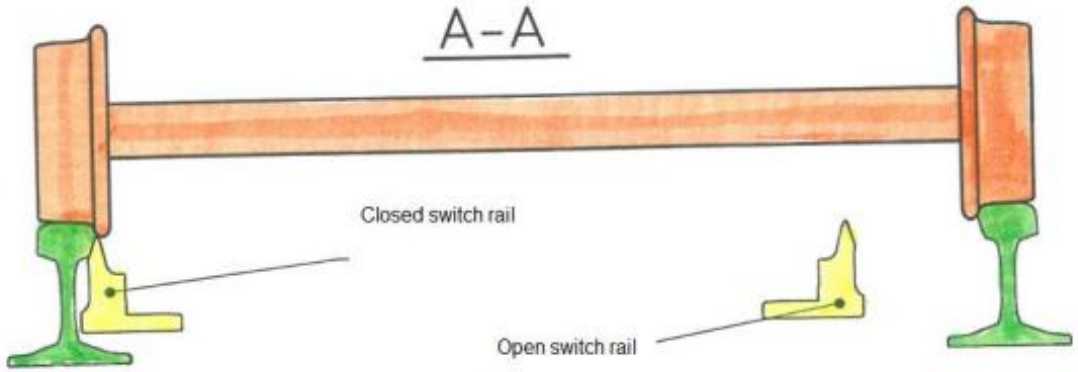


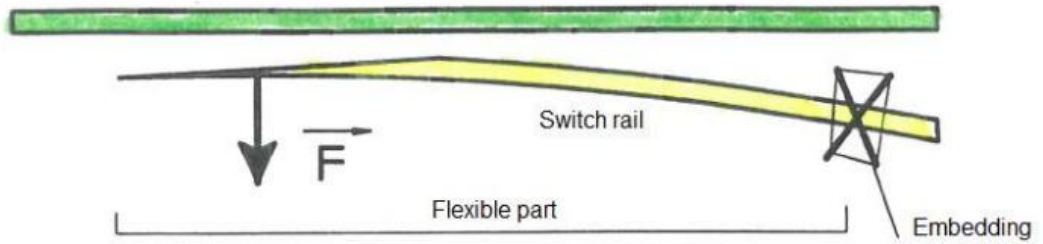
ADVANTAGES

- Best compromise between Safety and Availability
- Detectors have electrical contacts, free lubrication & adjustment, contacts self-cleaned.
- Applied in 12 VHS Networks
- Experience : 40 Years

SIGNALING & SAFETY

TRAILABILITY / NON TRAILABILITY



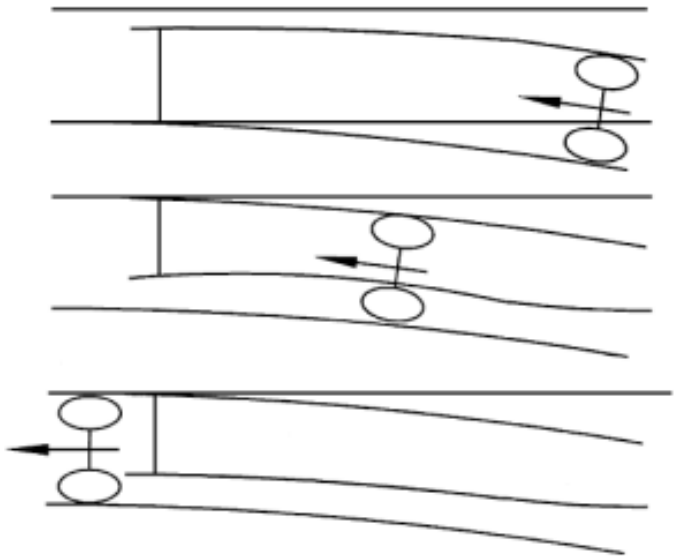


DESCRIPTION

- The goal is to allow the train to roll over the switch and the swing nose in case, in complete safety without a point being in a dangerous position, i.e. outside the tolerances of the application on the stock rail or the cradle.
- The "shifting" of a point must be prevented before, during and after the passage of the rolling stock.
- Two philosophies are applicable to these points:
  - **Clamping** : Maintaining of the point in position
    → Can be opened under a certain force (trailable ability)
  - **Locking** : Maintaining/locking of the point in position
    → Cannot be opened without destruction of the mechanism

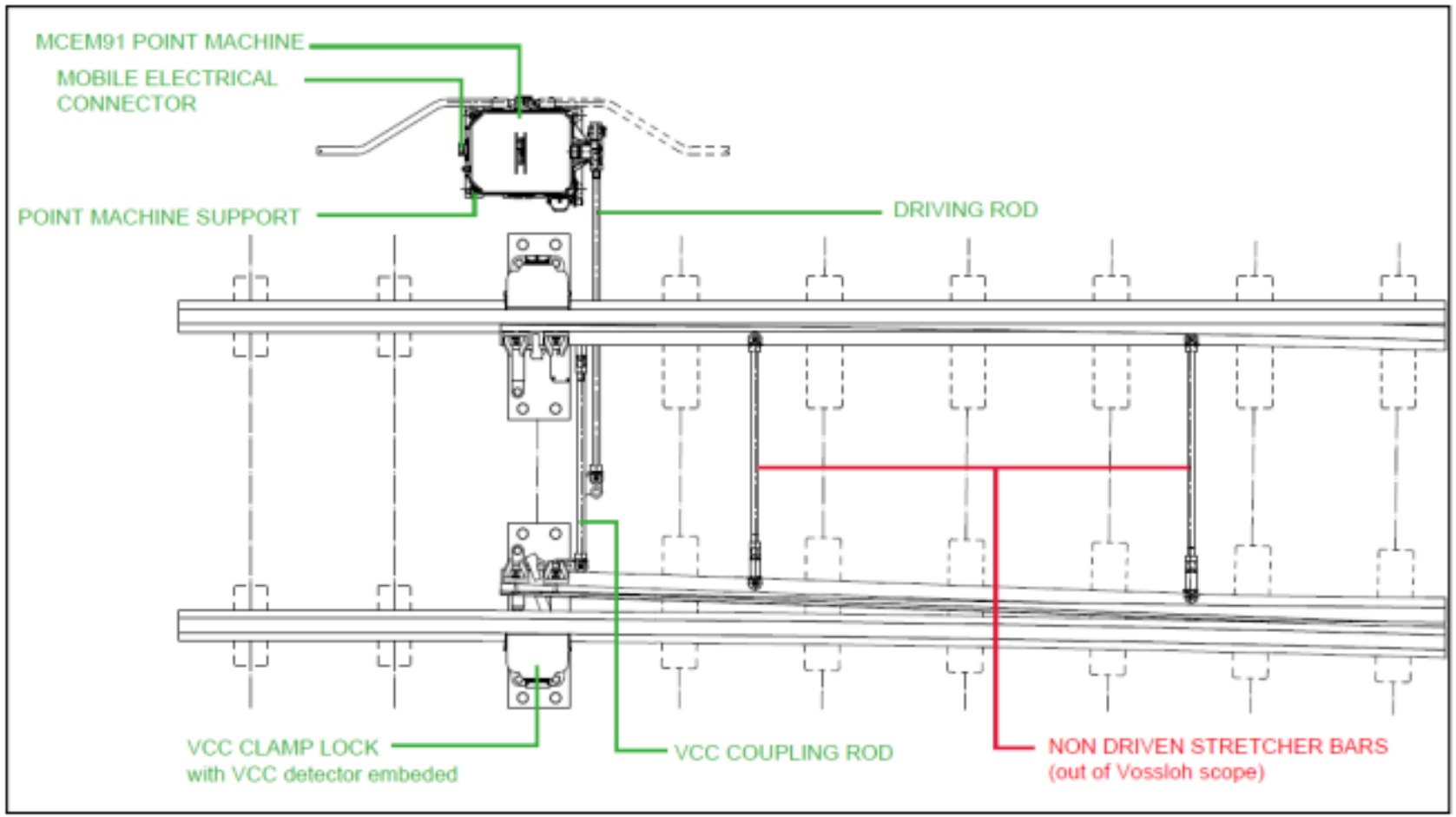
In all configurations the train must cross the turnout and not derail

Trailability



ALD IN IN MAIN LINE:

NON TRAILABLE ARRANGEMENT

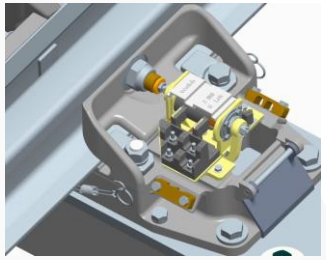


- Point Machine MCEM91
- VCC Locking device
- KV controller

MCEM91

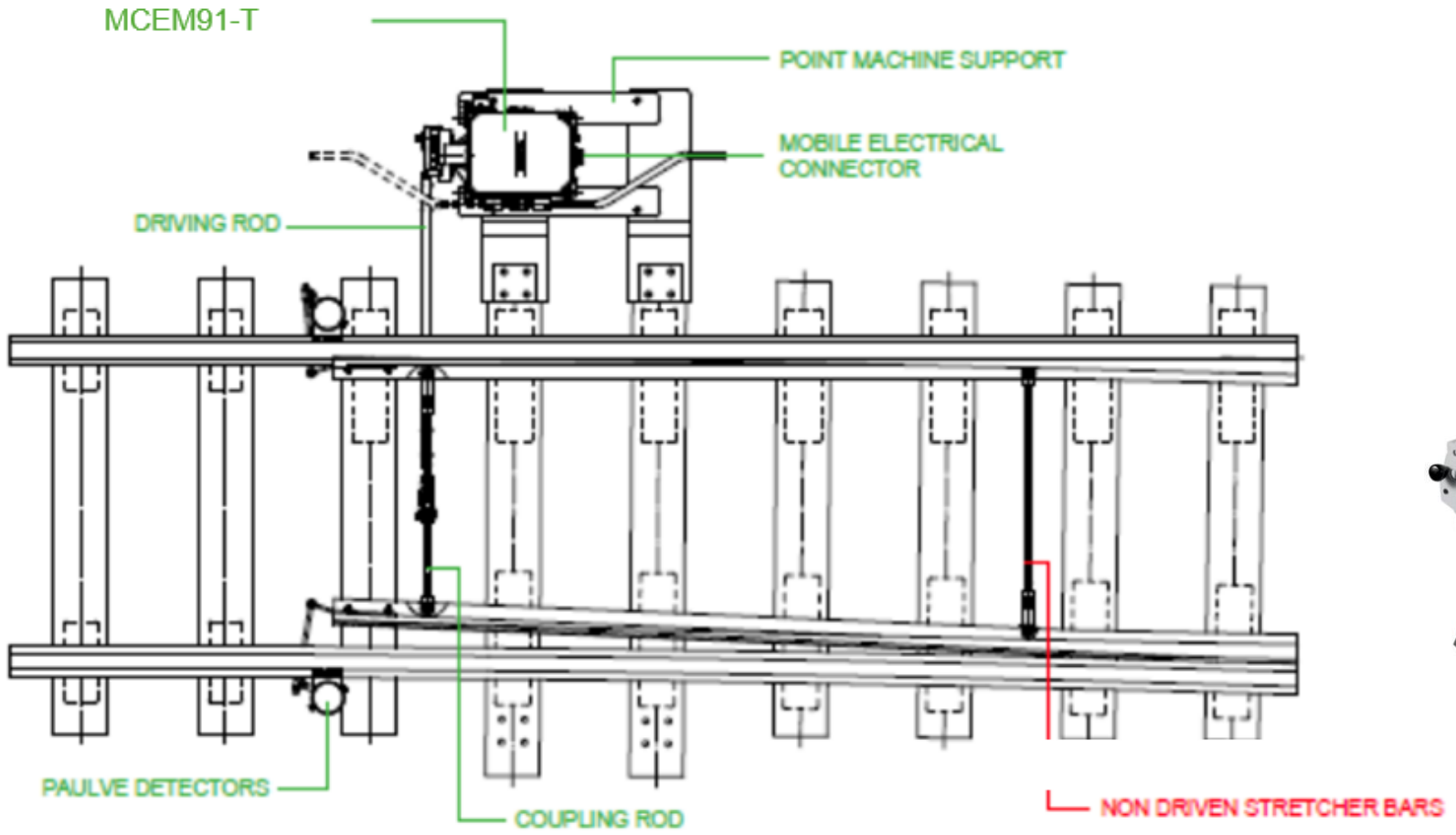
VCC

KV Detector



ALD IN IN DEPOT:

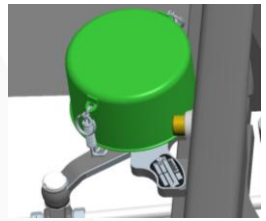
TRAILABLE ARRANGEMENT



- Point Machine MCEM91T
- Paulve controller

MCEM91T

Paulvé Detector



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06

PROPOSAL FOR HANOI METRO

HANOI METRO

T2

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6.1

DESIGN GUIDELINES

HANOI METRO

T2

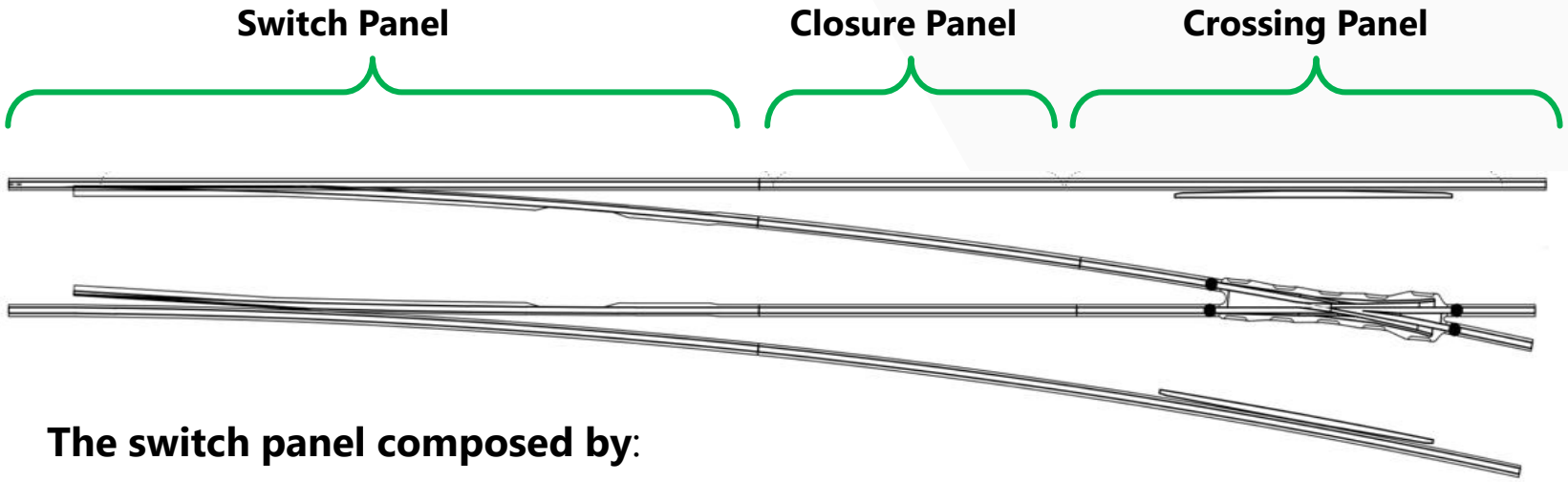
DESIGN GUIDELINES

APPLICABLE STANDARDS FOR TURNOUTS IN HANOI

And Customer Design Guidelines – Technical Specifications

DESIGN GUIDELINES

SCOPE



The switch panel composed by:

One LH Half Switch composed by:	One RH Half Switch composed by:
1 Left Hand Straight Stock rail	1 Right Hand Curved Stock rail
1 Left Hand Curved tongue	1 Right Hand Straight tongue
A set of adjusted distance blocs with anti-creeping devices	A set of adjusted distance blocs with anti-creeping devices
A set of anti-creeping system	A set of anti-creeping system
A set of Slide Chairs	A set of Slide Chairs
A set of Heel Chairs	A set of Heel Chairs
Fastening elements	Fastening elements

The closure panel composed by:

- Closure rails
- Fastening elements

The crossing panel composed by:

- 1 fixed nose crossing
- Outside rails of the crossing
- All fastening elements
- Checkrails with checkrails supports

The ALD composed by:

- 1 set of VCC locking devices
- 1 Point Machine
- Back Drive systems
- Point machine/transmission brackets
- Detection device

DESIGN GUIDELINES

DESIGN PARAMETERS

Gauge	1 435
Rail (Vignole type) :	
Main Line	60E1
Depot	54E1
Rail Inclination	1/40
Maximum axle load	16 tons
Maximum speed :	
Main Line	110 Km/h
Main Line Access	40 Km/h
Depot	15 Km/h
Minimum curve radius :	
Main Line	300 m
Access Main Line	160 m
Depot	120 m
Maximum gradient :	
Main Line	3,5 %
Access Main Line	3 %

Main Line Rails:

Rail Profile	60E1	60E1A5
Steel Grade	R350HT	R350HT
Application	Stock Rails Closure Rails Tongue Rails (REJ)	Switch Tongues

Depot Rails:

Rail Profile	54E1	54E1A1
Steel Grade	R260	R260
Application	Stock Rails Closure Rails	Switch Tongues

Main Line and Depot Rail:

Rail Profile	33C1
Steel Grade	R260 or R320Cr

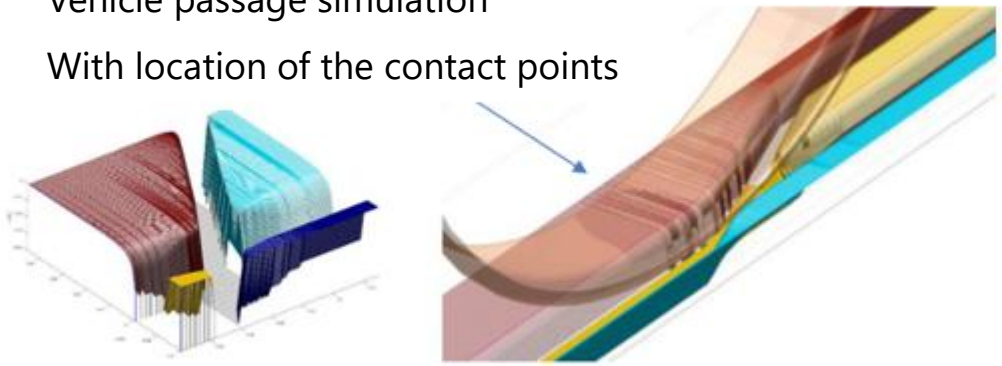
DESIGN GUIDELINES

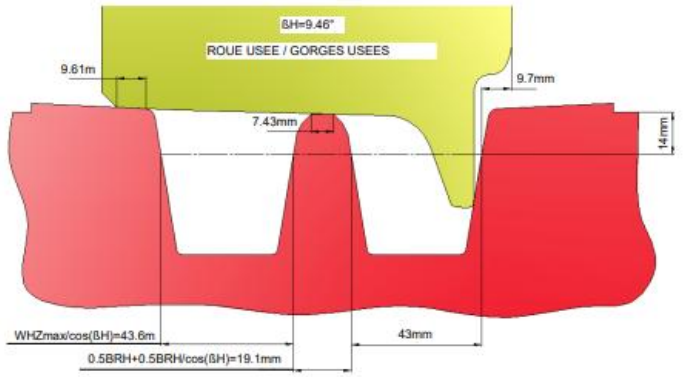
RAIL WHEEL INTERACTION COMPATIBILITY

- Switches and crossings are designed to suit the wheel profile and the rolling stock.
- A Wheel/Rail study will be made taking in account the following data:
  - Modeling the rolling stock : New and worn limit
  - Modeling of S&C to make them compatible with the calculation software
  - Synoptic of the safety file :
    - Determination and comparison with the verified turnout of the angle of attack corresponding to each geometry.
    - Determination and comparison with transverse dimensions
    - Control of the minimum bearing for every crossing during load transfer (this will be checked for fixed points)
    - Presentation of the document with the results of the calculations and the conclusions

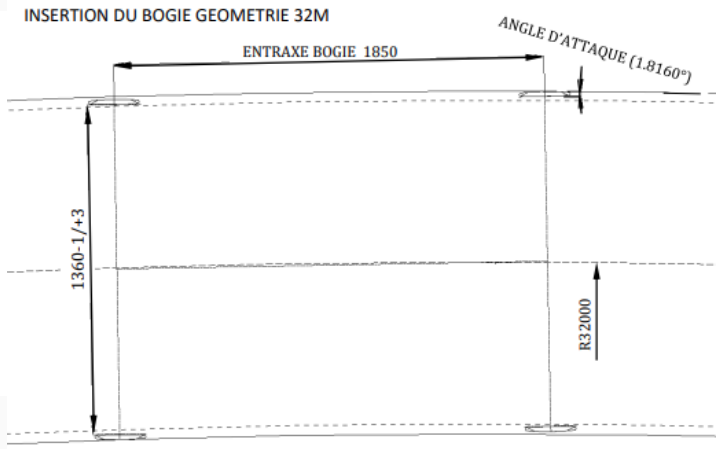
Vehicle passage simulation

With location of the contact points





Minimum bearing



Attack angle

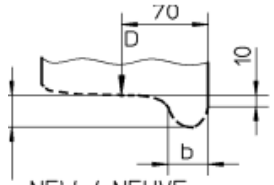
DESIGN GUIDELINES

ROLLING STOCK DATA

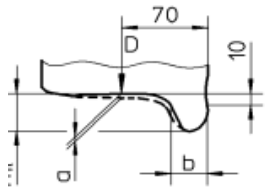
› To do the Rail/Wheel calculations, Vossloh needs the Rolling Stock data as follows :

KEY WHEEL DIMENSIONS

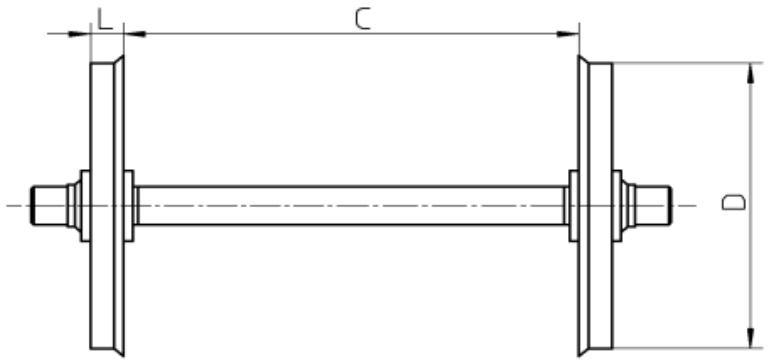
CARACTERISTIQUES DE LA ROUE



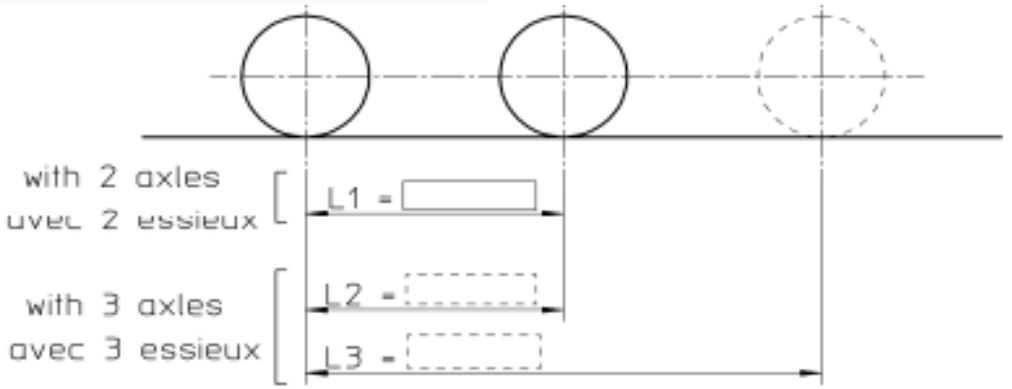
NEW / NEUVE

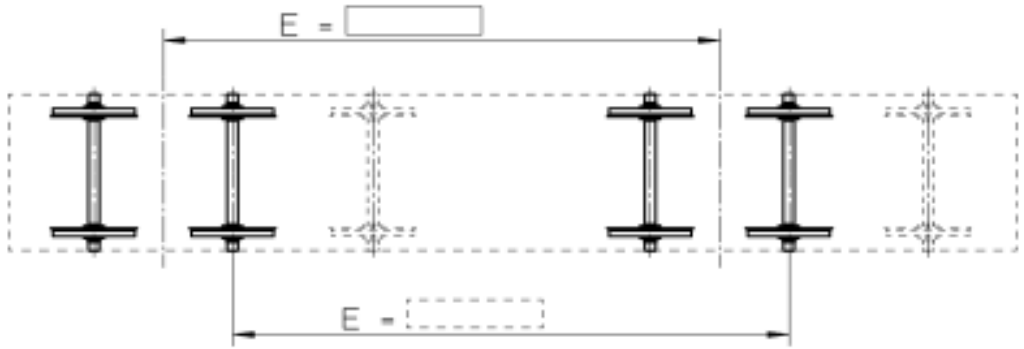


WORN / USEE



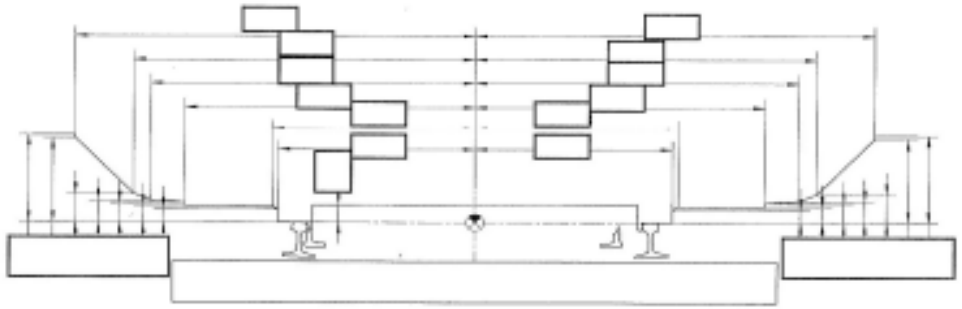
	a	b		C		D		h_{fl}	
	WORN USEE	NEW NEUVE	WORN USEE	NEW NEUVE	WORN USEE	NEW NEUVE	WORN USEE	NEW NEUVE	WORN USEE
NOMINAL									
MAXI									
MINI									





KINEMATIC GAUGE OF THE LOW PARTS

GABARIT CINEMATIQUE DES PARTIES BASSES

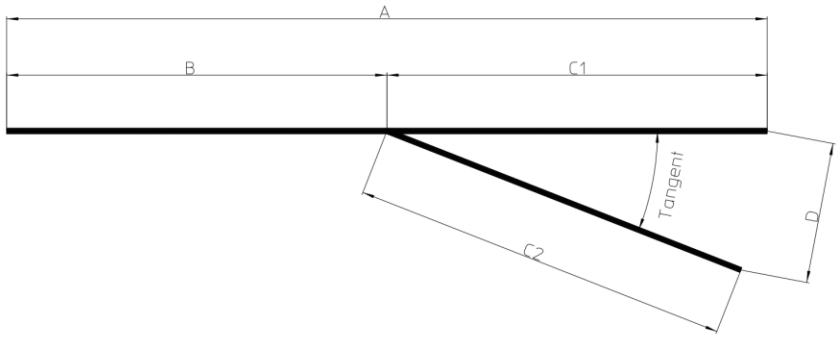


Gabarit selon la norme: Oui ☐ Non ☐
Kinematic gauge according to standard: Yes No
Gabarit spécifique client; définition disponible sous :
Kinematic gauge according to customer technical specification:

DESIGN GUIDELINES

TURNOUT GEOMETRIES

Turnout	A (m)	B (m)	C1 (m)	C2 (m)	D (m)	R (m)	Design Speed in Mainline (km/h)	Speed in Diverging (km/h)
ST-Tg.1/6-R=100m	20 346	8 276	12 070	12 070	1 991	100	110	25
ST-Tg.1/7-R=140m	23 999,5	9 949,5	14 050	13 646	1 992	140	110	30
ST-Tg.1/9-R=190m	28 268	10 523	17 745	17 745	1 963	190	110	35
ST-Tg.1/9-R=300m	33 643	16 615	17 028	17 028	1 883	300	110	45
ST-Tg.1/12-R=500m	42 771	20 797	21 974	21 974	1 827	500	110	60



Important :

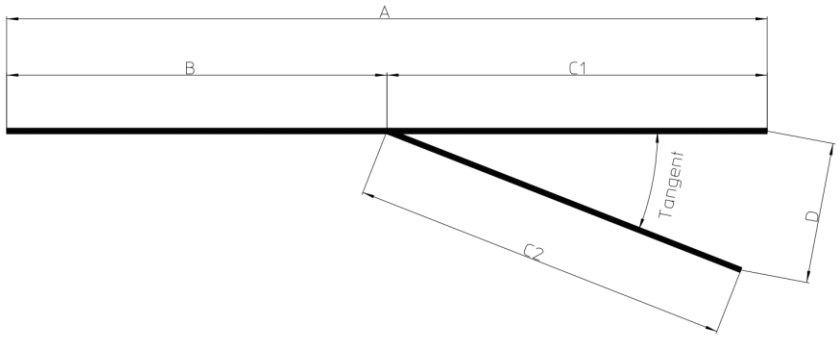
- Vossloh preserve the framework of the UIC geometries as theoretical ones but adapt them to the new technologies and Vossloh safety rules.

- Hereafter we present the updated current geometries offered by Vossloh, but every special geometry can be considered.

DESIGN GUIDELINES

TURNOUT GEOMETRIES

Turnout	A (m)	B (m)	C1 (m)	C2 (m)	D (m)	R (m)	Design Speed in Mainline (km/h)	Speed in Diverging (km/h)
ST-Tg.1/9-R=190m	28 268	10 523	17 745	17 745	1 963	190	110	35
N°8	26 172	11 838	14 334	14 334	1 788	165,328	110	37
ST-Tg.1/9-R=300m	33 643	16 615	17 028	17 028	1 883	300	110	45
N°10	32 703	15 283	17 420	17420	1 737	259,496	110	47



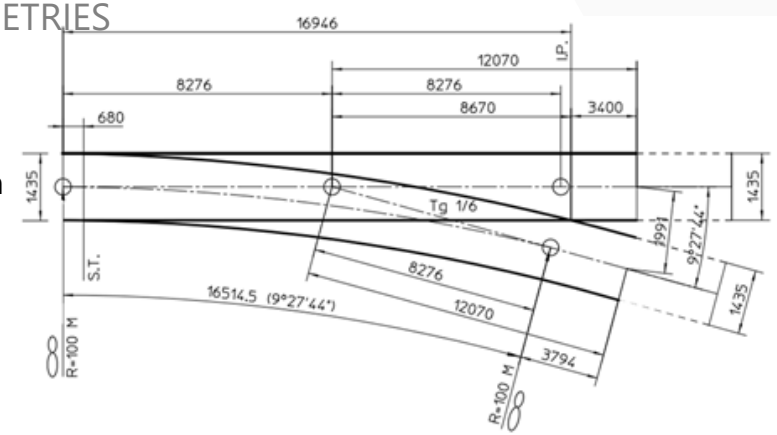
Important :

- Geometry with similar performance in both range
- The Speed is nearly the same
- Rail is not linked to geometry :
  JS and EN rails are adaptable for every geometry

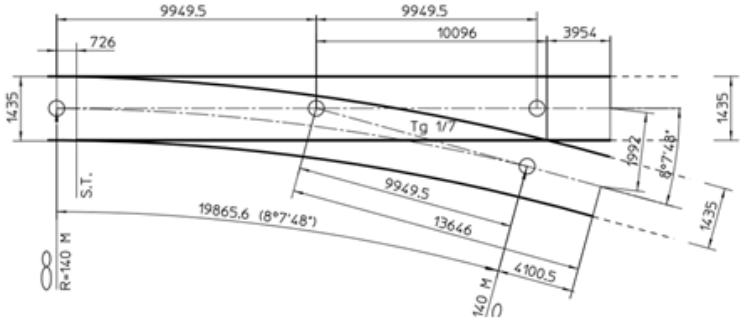
DESIGN GUIDELINES

TURNOUT GEOMETRIES

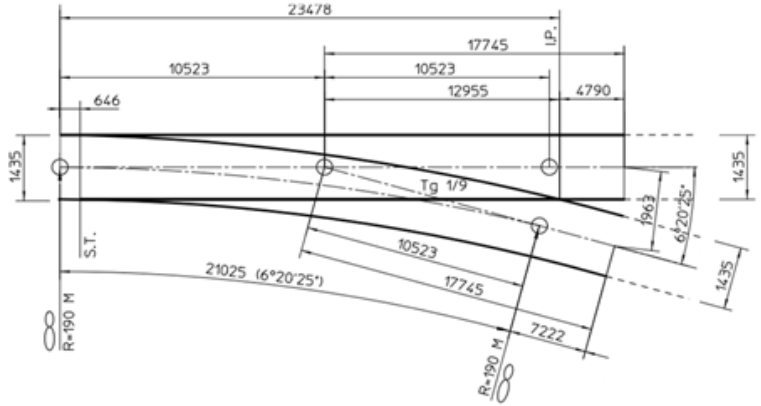
› **ST-Tg.1/6-R=100m**



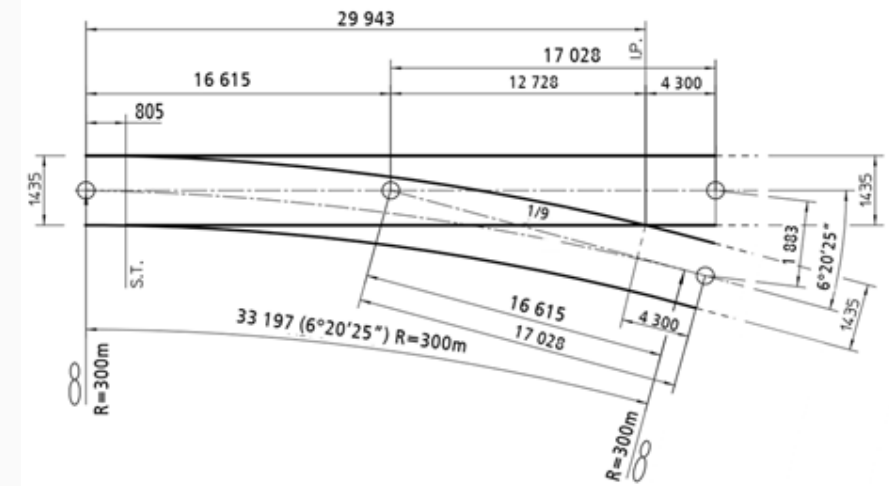
› **ST-Tg.1/7-R=140m**



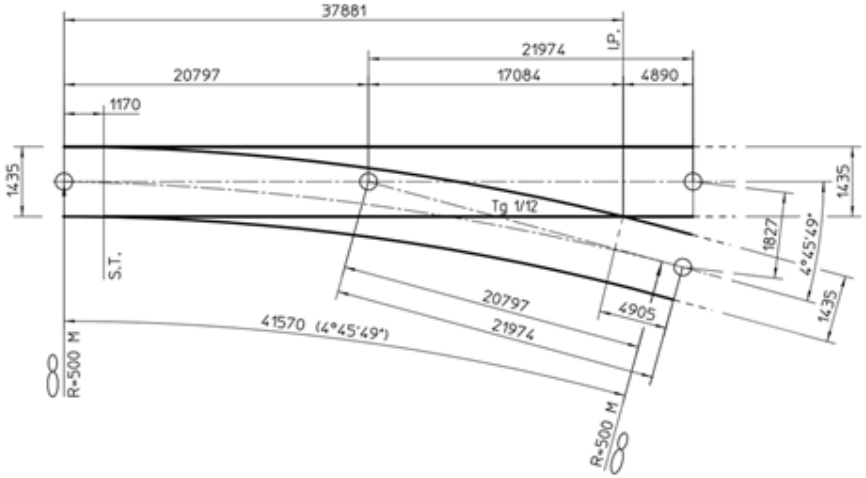
› **ST-Tg.1/9-R=190m**



› **ST-Tg.1/9-R=300m**



› **ST-Tg.1/12-R=500m**



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6.2

TRACK SUPPORT

V-Met

HANOI METRO

T2

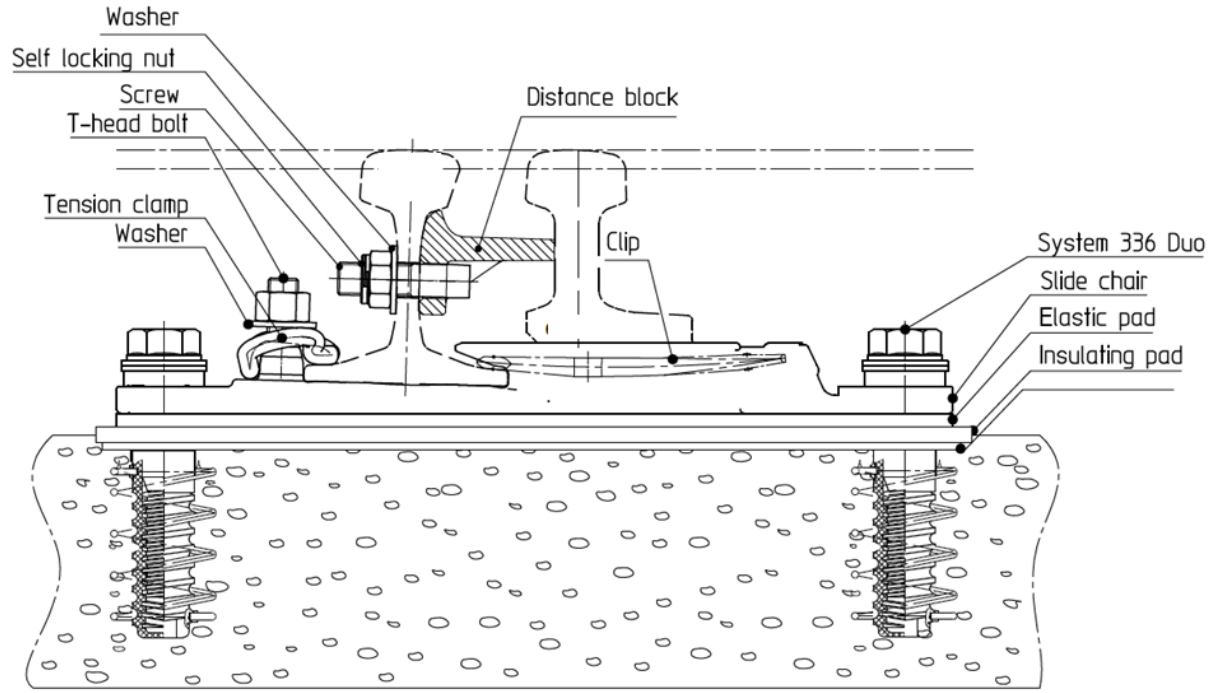
TRACK SUPPORT

IBAV SYSTEM

- The IBAV type slide chairs are fitted onto the stock rail by an internal AT type fastening and an external SKL12 fastening and contains a 1/40 inclination.
- The slide chair is fastened in the concrete slab with Vossloh 336 Duo fastening system.
- The slide chairs are casted

Material: EN GJS 400

Technical Specifications: EN 1563 EN 13481-7

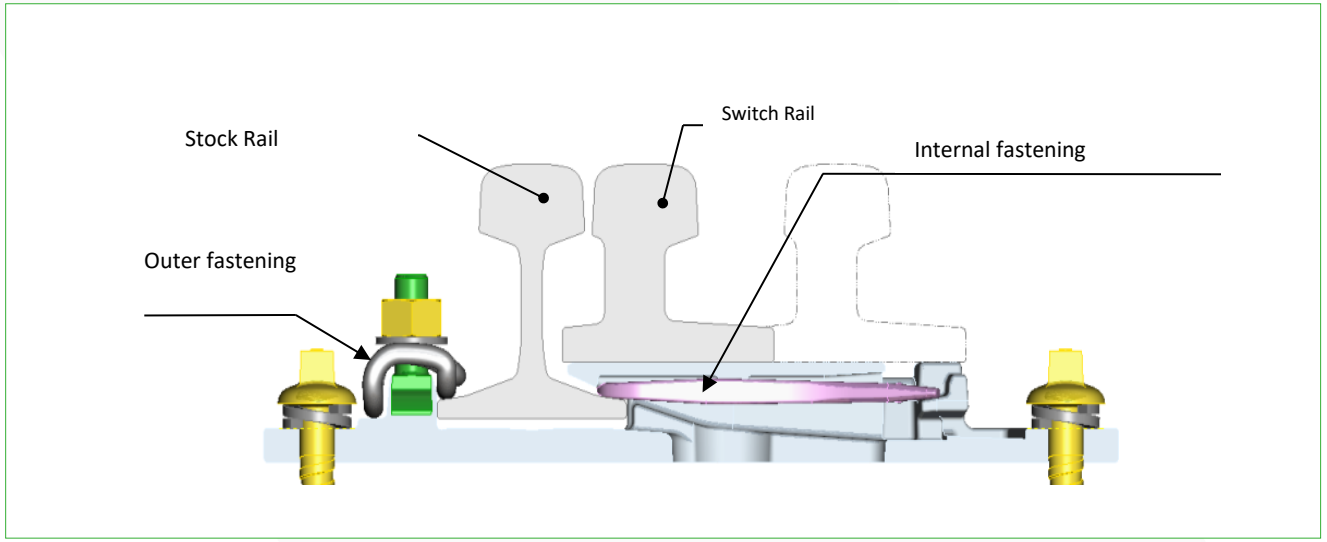


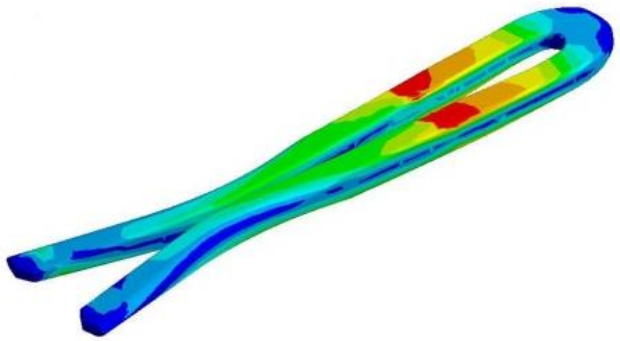
TRACK SUPPORT

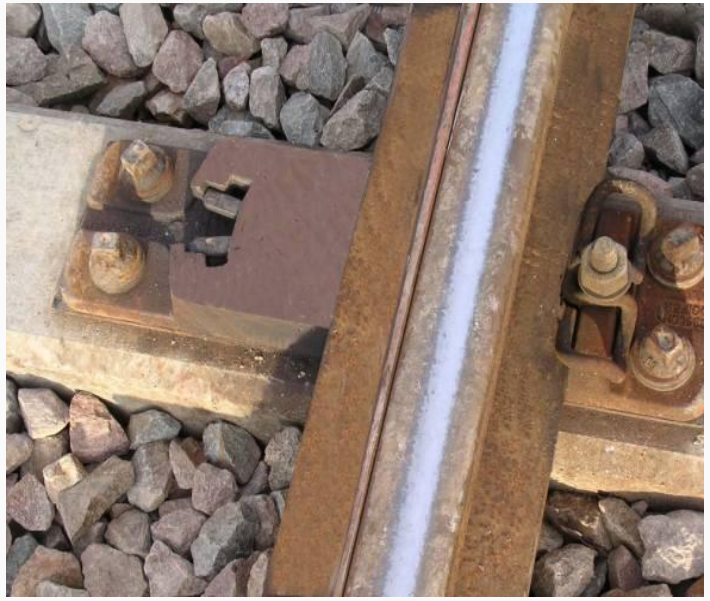
IBAV SYSTEM

Advantages:

- Easy Assembly
- All type of rails
- All types of laying
- All type fastenings
- Increased service life
- Reduction of lateral stresses
- Reliable System

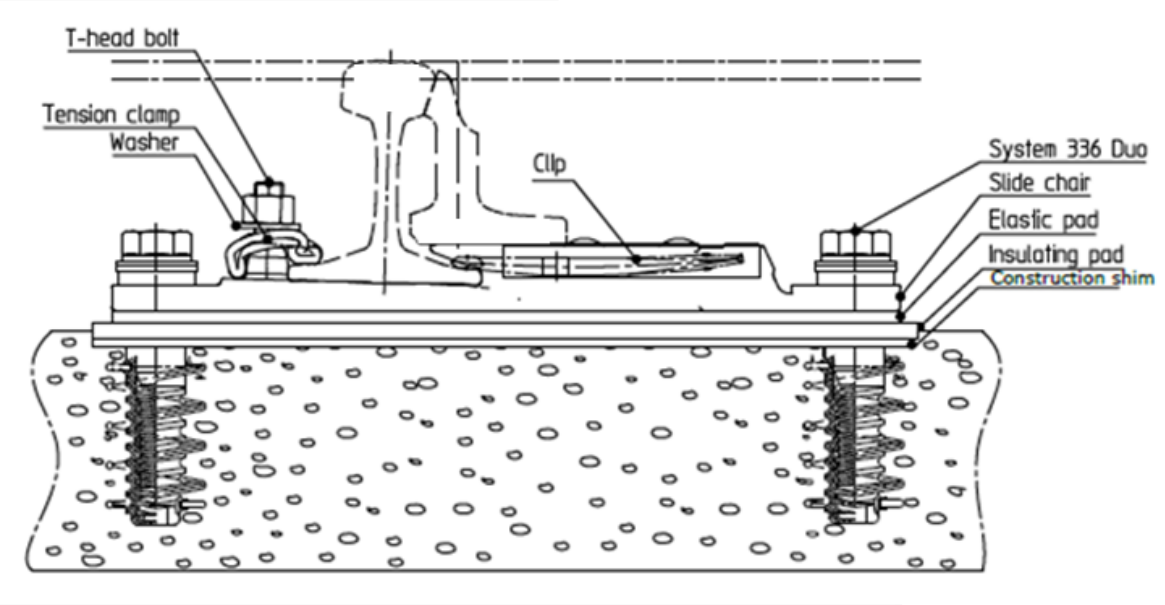






TRACK SUPPORT

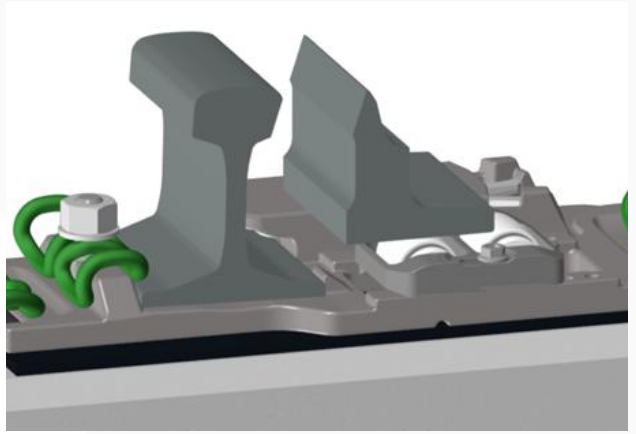
IBAV SYSTEM WITH ROLLERS



- The IBAV type slide chairs with roller device are fitted onto the stock rail by an internal AT type fastening and an external SKL12 fastening and contains a 1/40 inclination.
- The slide chair is fastened in the concrete slab with Vossloh 336 Duo fastening system.
- The slide chairs are casted

Material: EN GJS 400

Technical Specifications: EN 1563 EN 13481-7



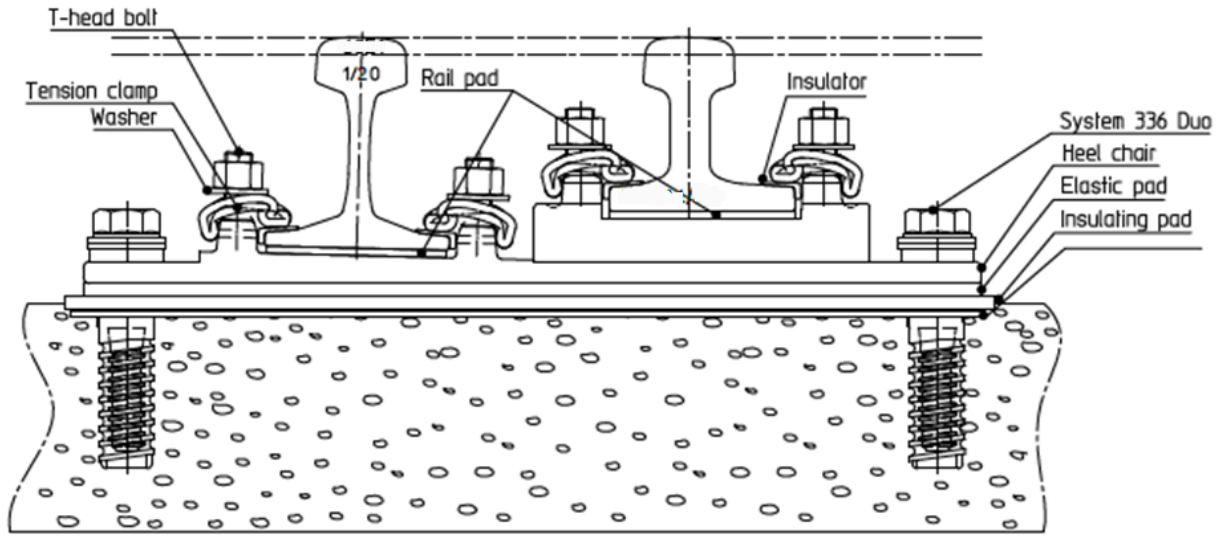
TRACK SUPPORT

HEEL CHAIR

- The heel baseplate is machined in a block.
- The Stock and Switch rail are fitted with an elastic fastening SKL12.
- The heel baseplate is fastened in the bearer with Vossloh 336 Duo fastening system.

Material: Steel S 355 J2+N

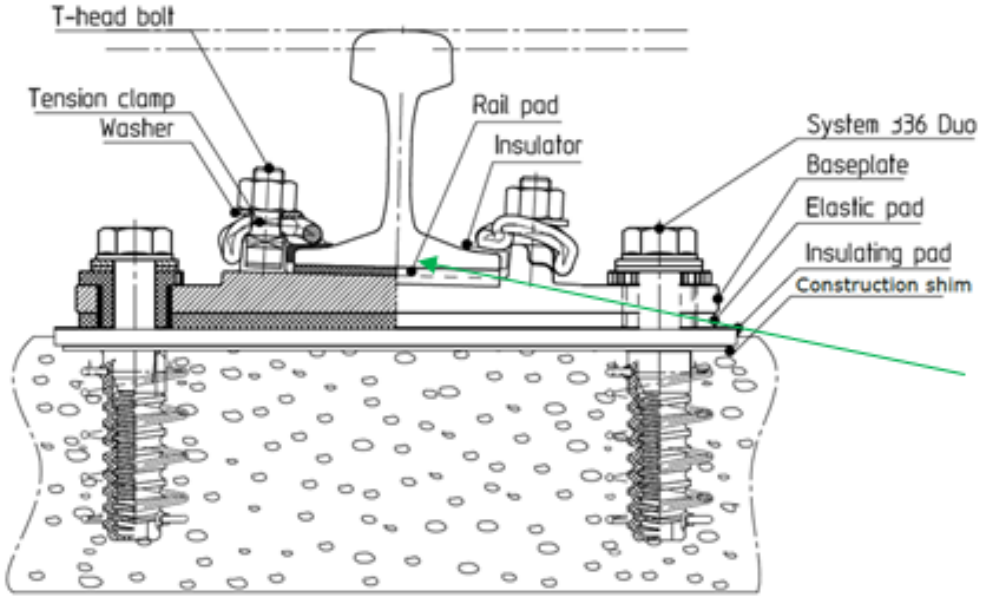
Technical Specifications: EN 10025-2



TRACK SUPPORT

FASTENING SYSTEM

System 336 Duo Highly elastic rail fastening for metro –the ribbed base plate solution for slab track



Inclination
1/40

TRACK SUPPORT

FASTENING SYSTEM

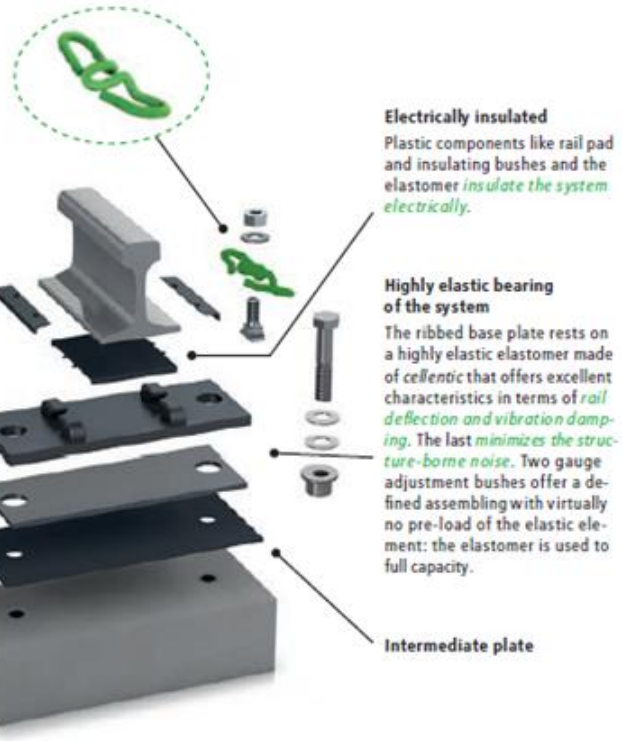
System 336 Duo Highly elastic rail fastening for metro –the ribbed base plate solution for slab track

System 336 Duo

Elastic. Safe. Resilient. Flexible.

The W-shape of the Skl 24 provides safety

For meeting the required *rail creep resistance* two highly elastic, independently acting spring arms steadily hold the rail down; the middle bend acts as an additional *tilting protection*. With its high fatigue strength, it resists the dynamic vertical movements that are caused when the vehicle rolls over the rail. The system is *maintenance-free*: Due to the permanently acting tension, Skl and screw cannot loosen, the middle bend prevents the spring arms from plastic deformation.



Electrically insulated

Plastic components like rail pad and insulating bushes and the elastomer *insulate the system electrically*.

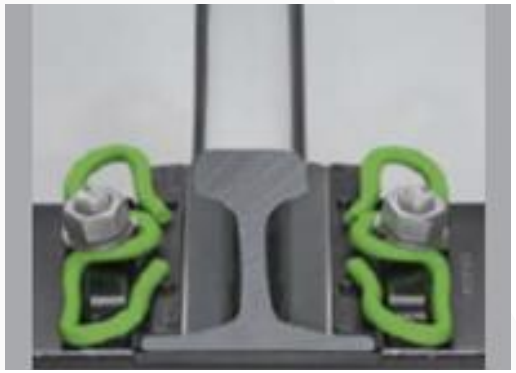
Highly elastic bearing of the system

The ribbed base plate rests on a highly elastic elastomer made of *cellentic* that offers excellent characteristics in terms of *rail deflection and vibration damping*. The last *minimizes the structure-borne noise*. Two gauge adjustment bushes offer a defined assembling with virtually no pre-load of the elastic element: the elastomer is used to full capacity.

Safely tied

By means of T-headed bolts, the Skl are safely mounted to the ribbed base plate. The ribbed base plate itself is fixed in the concrete track with two hexagon bolts and two plastic dowels.

Intermediate plate



Easy handling for installation and rail maintenance due to preassembly and exchangeability

- Flexibly applicable as single support point: no special shoulders (e.g. for concrete sleepers) required.
- Installation is possible both with top-down and with bottom-up method.
- For welding of the rail, no fastening elements have to be removed from the support point.
- The single support point can be delivered as preassembled component.
- All components can be replaced.
- Optionally applicable in turnouts.

TRACK SUPPORT

FASTENING SYSTEM

System 336 Duo Highly elastic rail fastening for metro –the ribbed base plate solution for slab track

Rail fastening system 336 Duo with tension clamp Skl 24		
Typical field of application	Urban transport/ Transit, slab track with ribbed base plates	
Axle load	≤ 18 t	
Speed	≤ 140 km/h	
Curve radius	≥ 80 m	
Height adjustment	+ 20 mm	
Gauge adjustment	± 16 mm	
Vertical fatigue strength of Skl 24	2.5 mm	
Static stiffness of *cellentic* intermediate plate	≥ 8 kN/mm	EN 13146-9: 2011
Relation of dyn./ stat. stiffness of *cellentic* intermediate plate	1.1	EN 13146-9: 2011
Toe load of Skl 24 (nominal)	9 kN	EN 13146-7: 2012
Electrical resistance	≥ 5 kΩ	EN 13146-5: 2003
Rail creep resistance	≥ 9 kN	EN 13146-1: 2012
System approval/ homologation		EN 13481-5: 2012

vossloh
enabling green mobility

6.3

TRACK FOR MAINLINE

HANOI METRO

T2

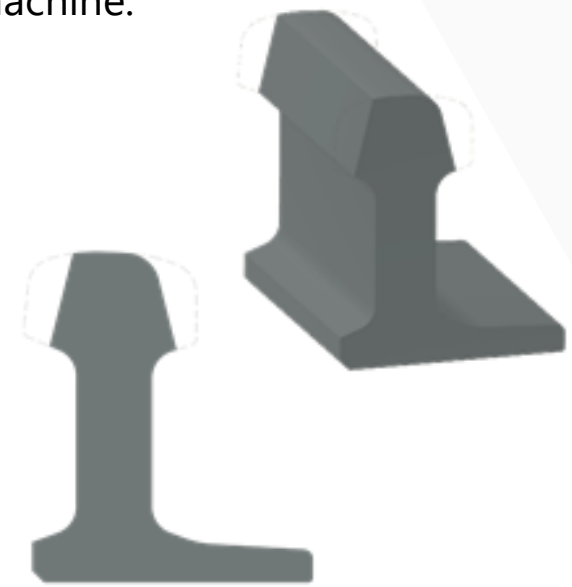
TRACK FOR MAINLINE

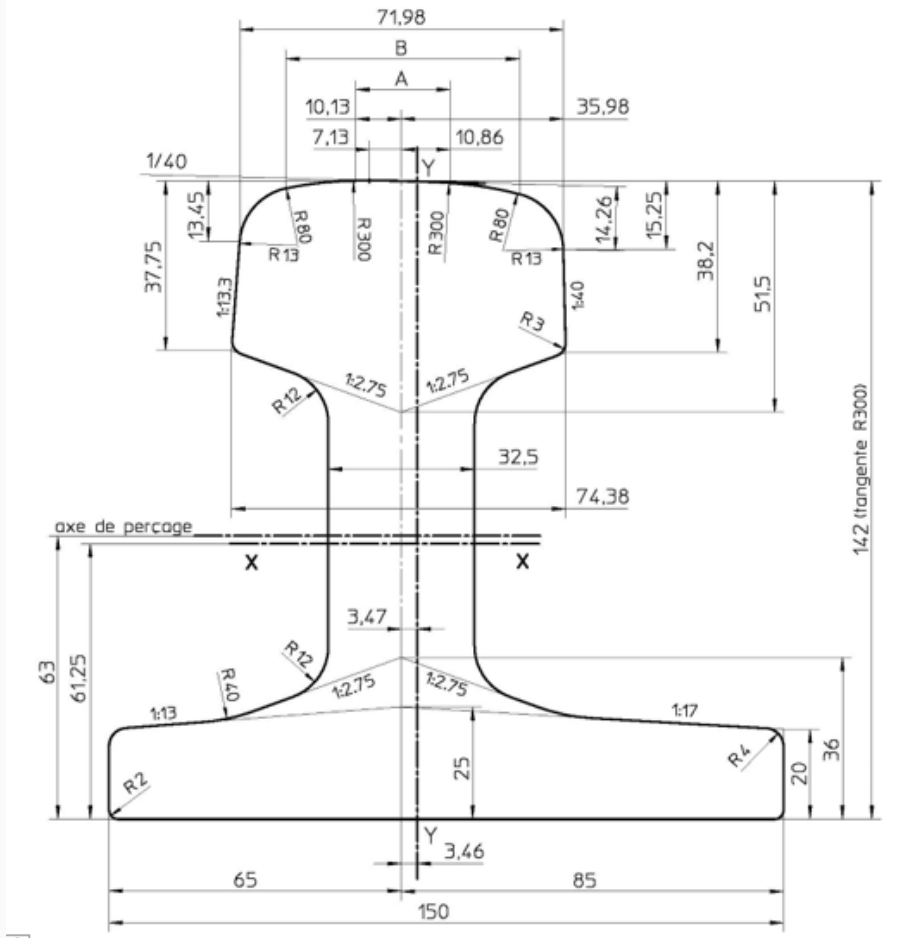
TONGUE FOR MAINLINE

- The elastic tongue without elastic chamber is made of 60E1A5 asymmetrical rail.
- The machining of the rolling surface takes in account the 1/40 canted laying and is forged on the heel to the 60E1 profile.
- The forging length of the heel is 450mm and the length of the transition area of the 2 rail profiles is 150 mm (Total length of forged area = 600mm maximum)
- The machining is made with a milling machine.
- The rail is fully treated.

Material: steel quality R350HT

Technical Specifications: EN 13674-2





Surface de la section *Cross-sectional area*	89,11 cm²	Moment d'inertie axe y-y *Moment of inertia y-y axis*	764,3 cm⁴
Masse par mètre *Mass per metre*	69,95 kg/m	Module d'inertie axe y-y (i/v) *Section modulus y-y axis (i/v)*	G / L = 111,6 cm³ D / R = 93,7 cm³
Moment d'inertie axe x-x (i/v) *Moment of inertia x-x axis (i/v)*	2035,8 cm⁴	Dimension indicative *Indicative dimensions*	A = 20,985 mm B = 51,978 mm

Plan suivant norme / *Drawing according to standard* NF EN 13674-2+A1 (2010)

60 E1A5	***60D40***	**6 420 3899**

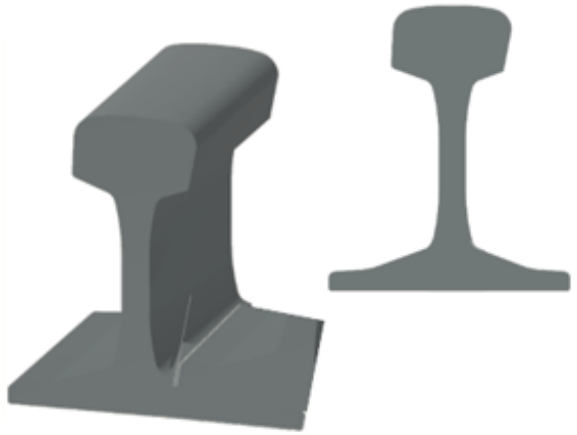
TRACK FOR MAINLINE

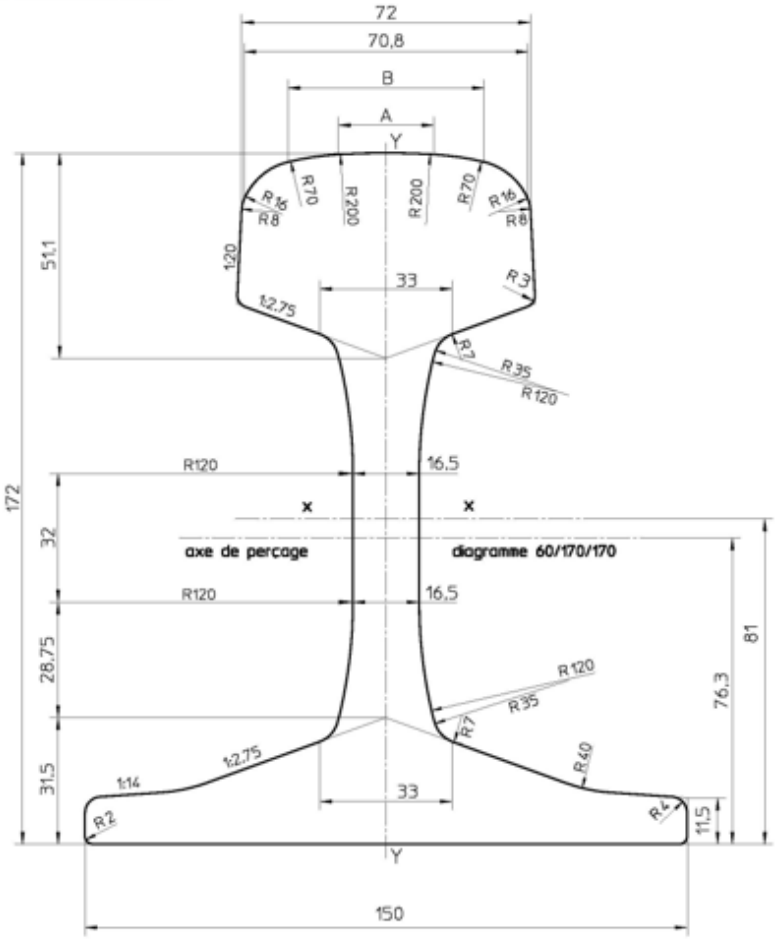
TONGUE FOR MAINLINE

- Rails 60E1 fully treated.
- The laying of the stock rail is canted 1/40. The machining is made on a milling machine.
- The web of the stock rail is drilled to fit the stops, Anti-Creep monitoring device, ALD, and the marking of the switch toe.

Material: steel quality R350HT

Technical Specifications: EN 13674-1





Surface de la section *Cross-sectional area*	76.70 cm²	Moment d'inertie axe y-y *Moment of inertia y-y axis*	512.3 cm⁴
Masse par mètre *Mass per metre*	60.21 kg/m	Module d'inertie axe y-y (i/v) *Section modulus y-y axis (i/v)*	68.3 cm³
Moment d'inertie axe x-x (i/v) *Moment of inertia x-x axis (i/v)*	3038.3 cm⁴	Dimension indicative *Indicative dimensions*	A = 20.456 mm B = 52.053 mm

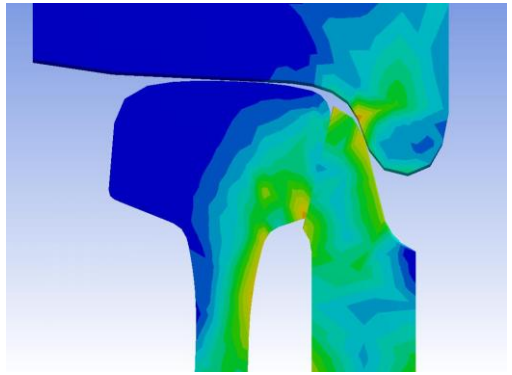
Plan suivant norme / *Drawing according to standard* NF EN 13674-1+A1 (2017)

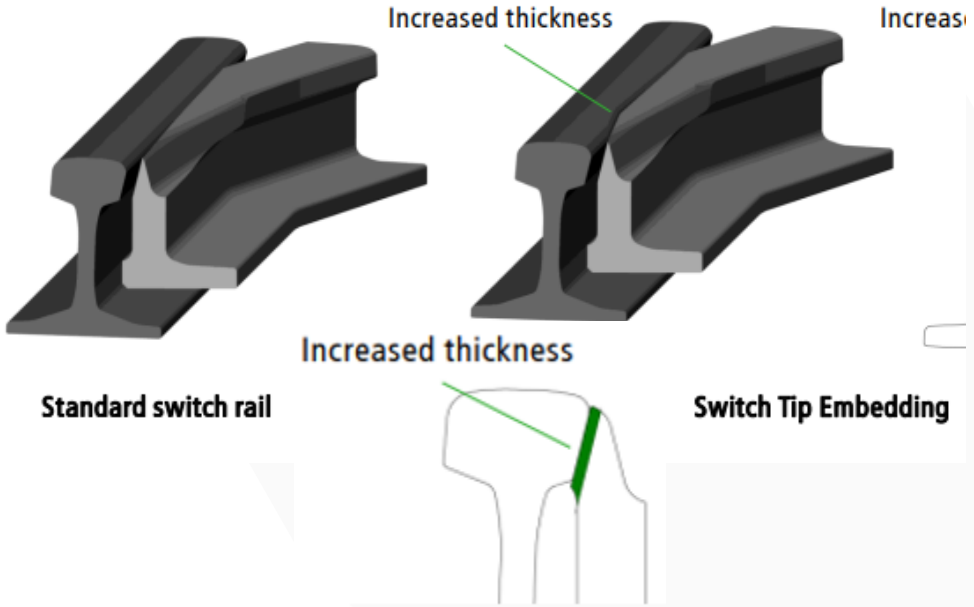
60 E1	*UIC 60*	6 420 2015

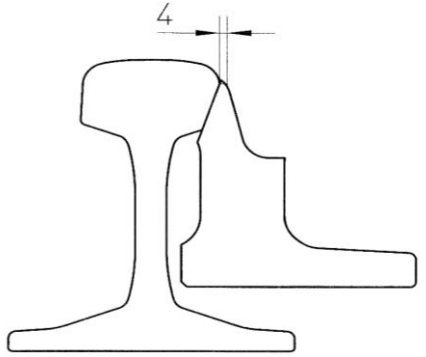
TRACK FOR MAINLINE

STO (SWITCH TIP OPTIMIZATION)

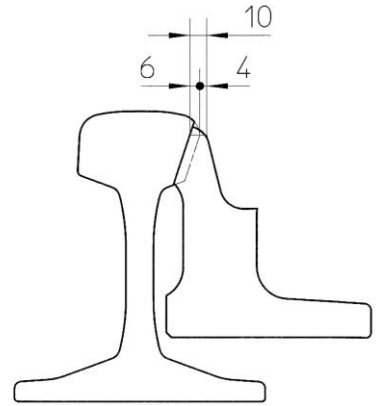
- Optimizing the lateral stability
- Better load distribution
- Reduction of bogie swaying effect
- Less maintenance
- Reduces the notching of the switch rail
- Increases the life span (LCC)



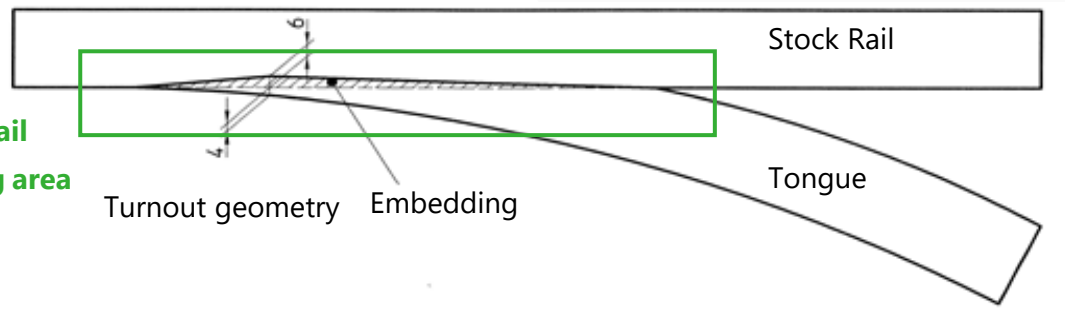




Standard Version

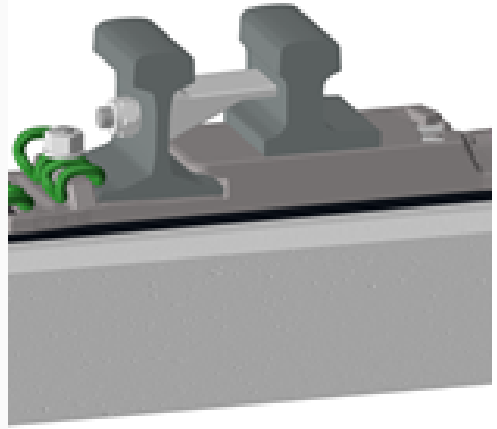


6 mm embedding



TRACK FOR MAINLINE

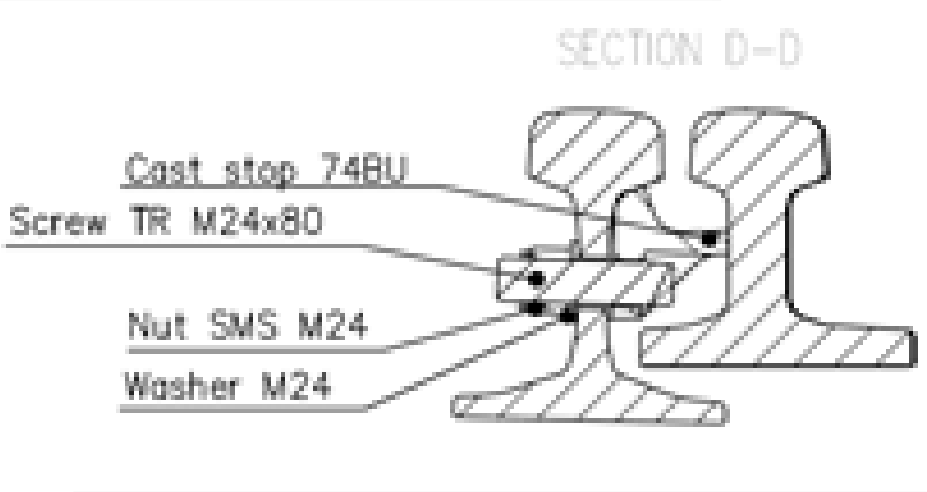
STOPS



- The stops are casted, adapted and fixed to the stock rail with high resistance bolts with self-protective nuts.

Material: EN GJS 500-7

Technical Specifications: EN 1563



TRACK FOR MAINLINE

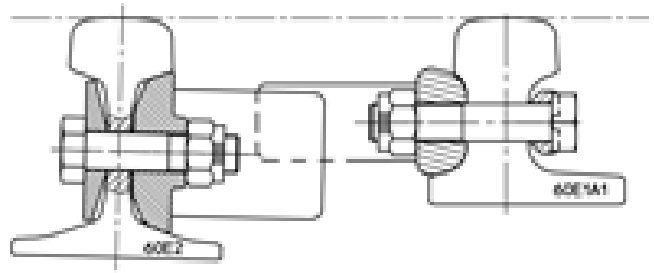
ANTI CREEP MONITORING DEVICE

Type 1

- The half switches are equipped with anti-creep-monitoring device.
- These anchors are casted and fitted with M27, 10-9 class bolts, special washers, and self-protective nuts.
- A set of profile plates ensure a good contact to guarantee an efficient fastening.

Material: EN GJS 400

Technical Specifications: EN 1563

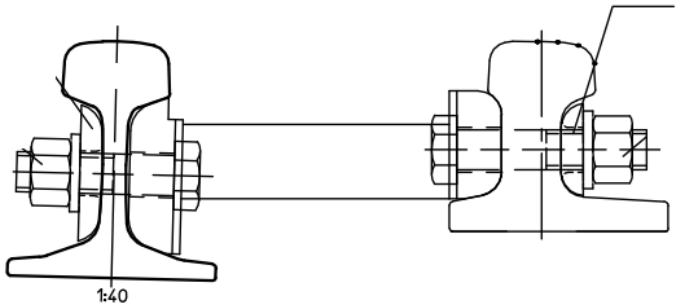


Type 2

- The half switches are equipped with heel block.
- These anchors are welded and fitted with M24, 10-9 class bolts, special washers, and self-protective nuts.
- A set of profile plates ensure a good contact to guarantee an efficient fastening.
- fastening.

Material: Steel S 355 J2

Technical Specifications: EN 10025



TRACK FOR MAINLINE

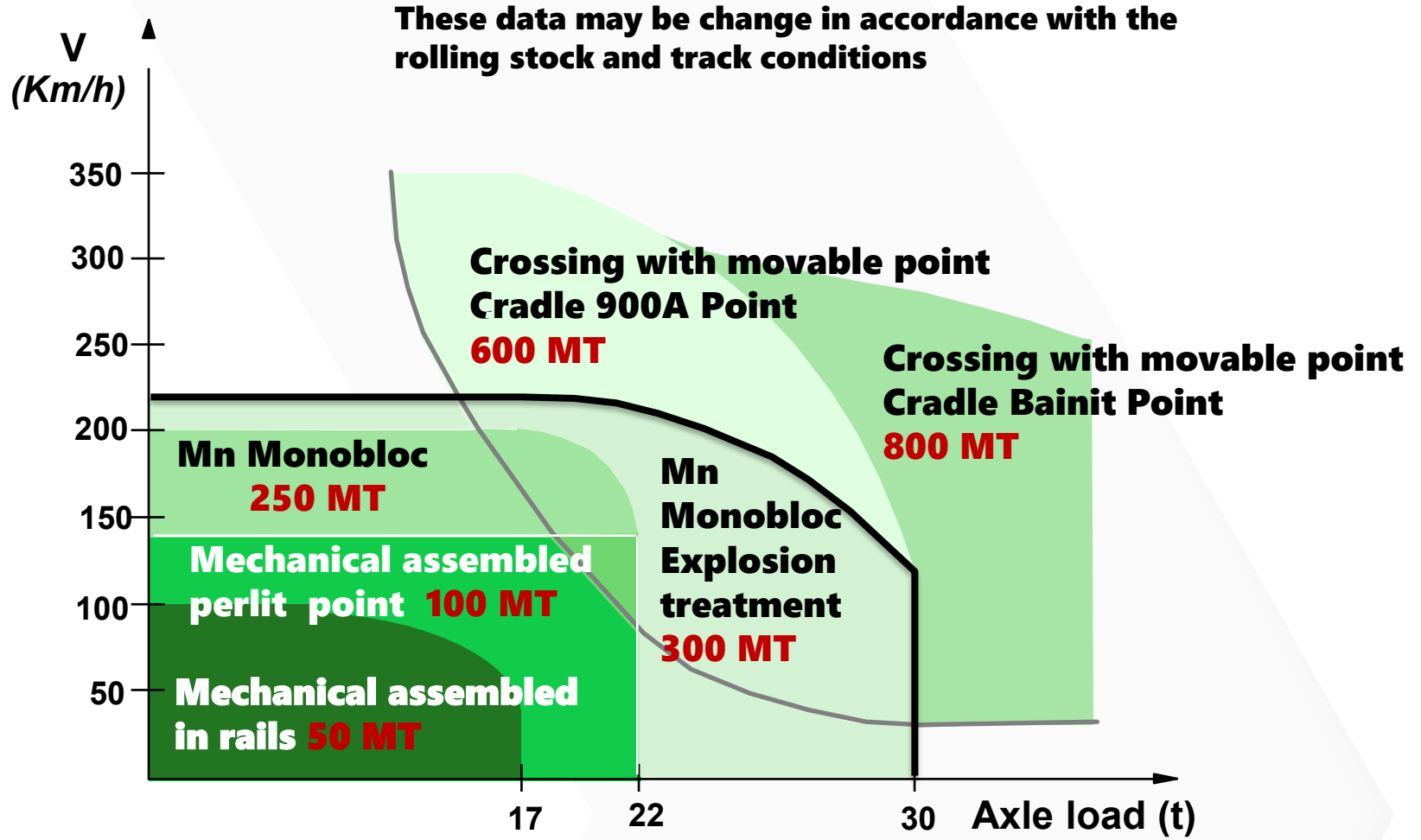
CROSSING

Traffic density data :

- Metro is a mass rapid transit
- Traffic assumption : 80 000 tons/day (equivalent to a heavily loaded line in conventional railways)
- Annual traffic : 29 MT

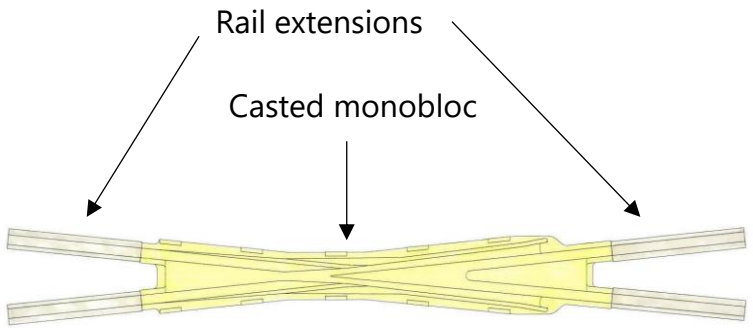
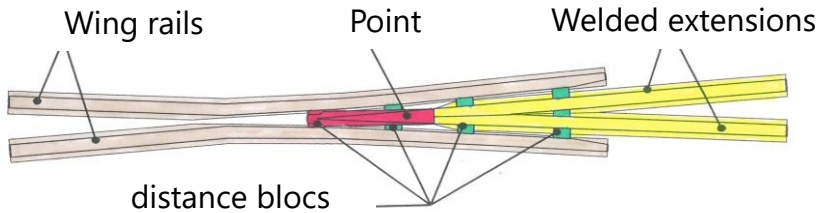
Vossloh Advise :

- Mn Monobloc crossing



TRACK FOR MAINLINE

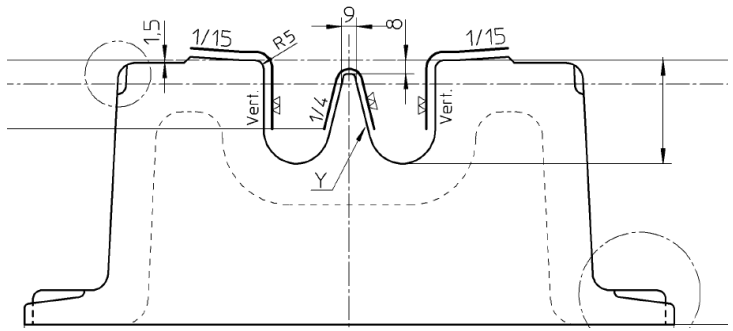
CROSSING COMPARISON

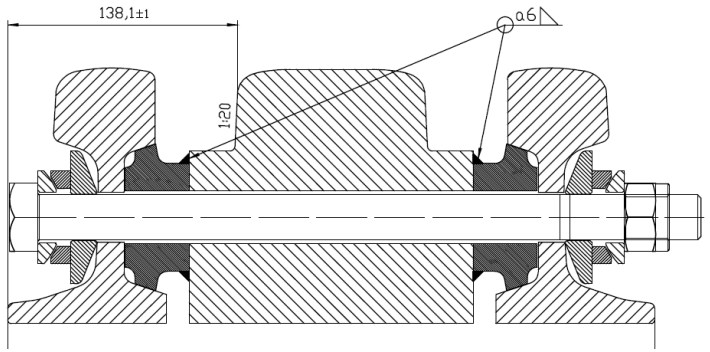
Casted Manganese Monobloc Crossing	Mechanical Assembled Crossing
The crossing consist in the following components: / 1 Casted manganese monobloc (12-14%) / 4 Electrical welded extensions 	The crossing consist in the following components: / 1 Point in heat treated steel / 2 Welded extensions / 2 Wing rails / 1 Set of distance blocs / 1 Set of bolts 

TRACK FOR MAINLINE

CROSSING COMPARISON

Casted Manganese Monobloc Crossing	Mechanical Assembled Crossing
/ The crossing is built according a casted monobloc construction / Optimizing of the lifted „wing rail“ in conformity with the rolling stock wheels	/ The crossing consist in a machined point on which the distance blocs are welded / The wing rails are placed and bolted on each side to the point / No possibility to optimize the wheel transfer by lifting of the rolling surface





TRACK FOR MAINLINE

CROSSING COMPARISON

Casted Manganese Monobloc Crossing

- Casted manganese steel monobloc
- Basic hardness: 180-220 HB (before hammering)
- After rolling: 500 HB up to 550 HB
- It exists a pre-hardening process to reach a hardness of 320 HB to 370 HB

Testing position	Hardness HB
Rolling surface	350 to 550

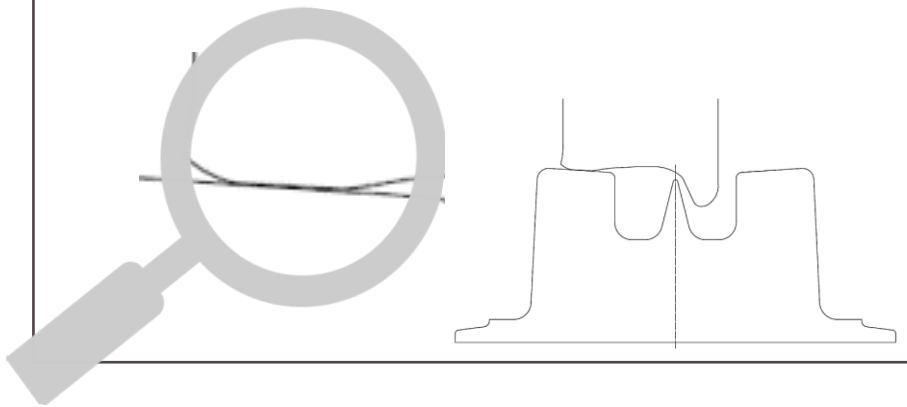
Mechanical Assembled Crossing

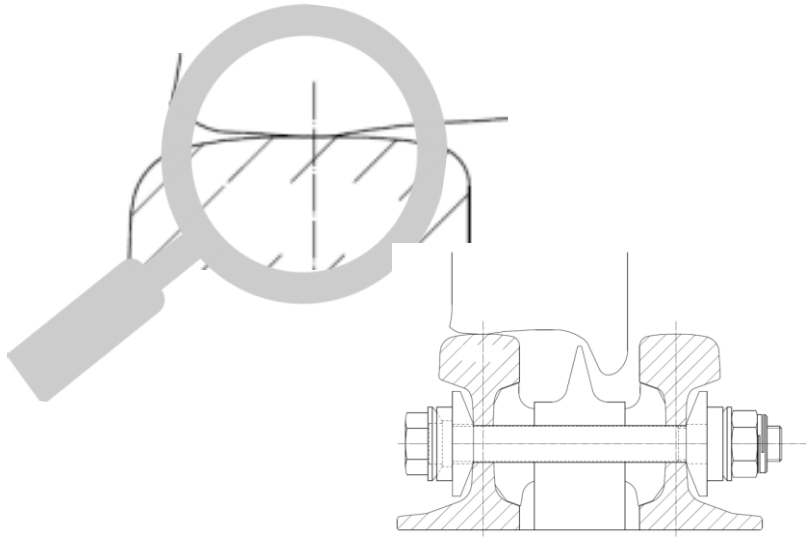
Testing position	Hardness HB
Rail head (Rolling surface) of the point or splice rail	350 to 550
1 mm below the rolling surface	360 to 400
15 mm below the rolling surface	> 300

TRACK FOR MAINLINE

CROSSING COMPARISON

Casted Manganese Monobloc Crossing	Mechanical Assembled Crossing
/ Lifting of the wing rail possible in casted version / Optimal passage over the „non guided“ area of the crossing / Good transfer even with extremely worn wheel / Optimized wheel transfer induct a low noise	/ Rolled wing rails do not allow lifting of the rolling surface / Lower guidance of the wheels induct higher noise and early wear

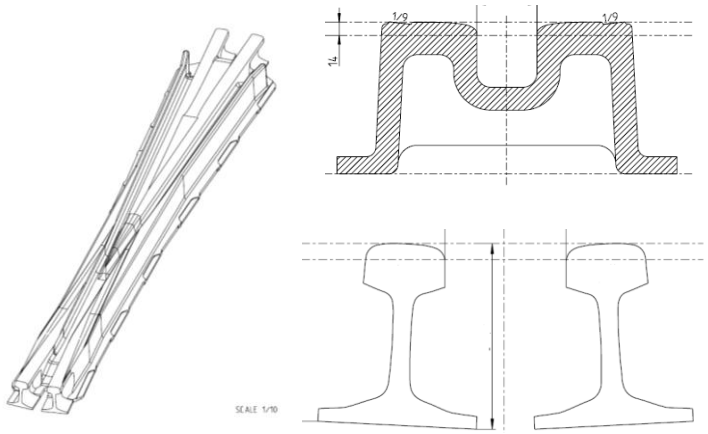


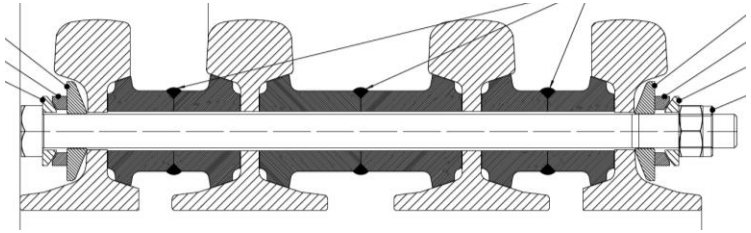


TRACK FOR MAINLINE

CROSSING COMPARISON

Casted Manganese Monobloc Crossing	Mechanical Assembled Crossing
/ The whole turnout is inclined in accordance with the track / No influence of a 1/40 laying: / Rolling surface is inclined / Rail extensions are welded according to the inclination angle	/ Only suitable for a vertical laying / The wing rail must be twisted to reach a 1/40 canted laying

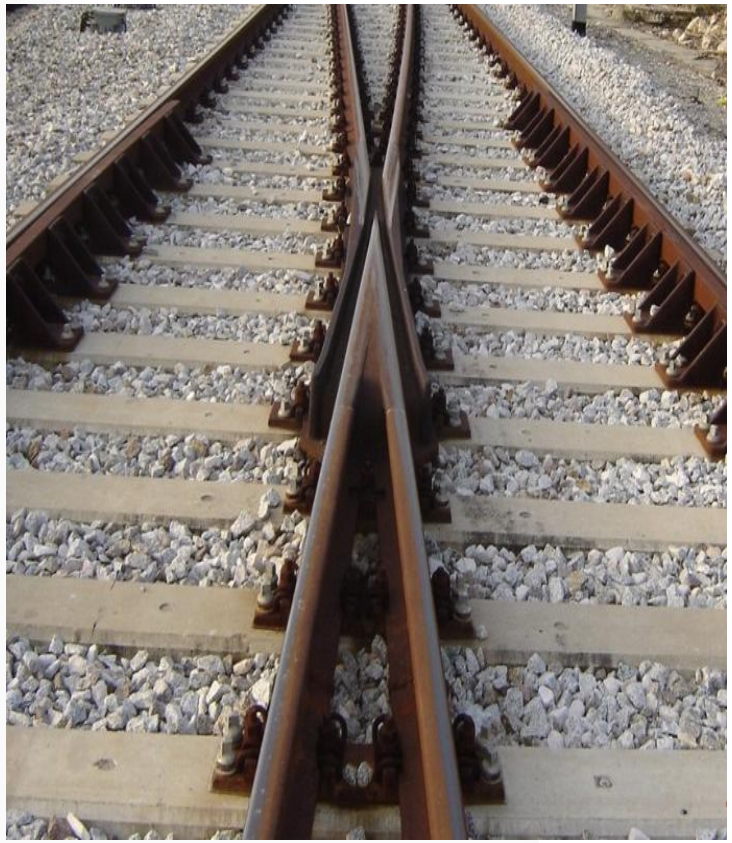


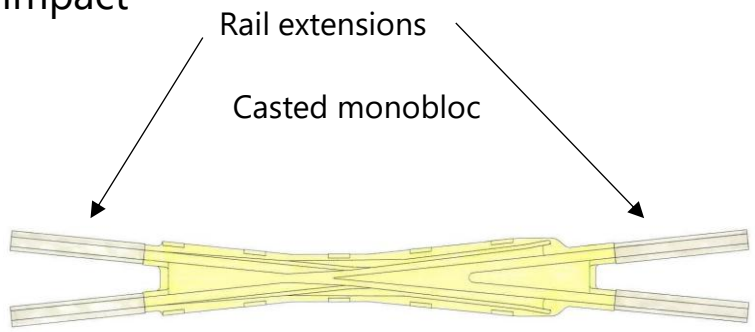


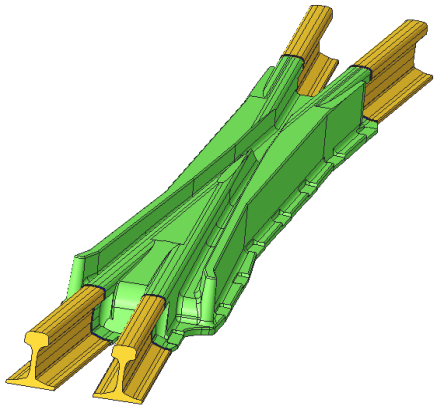
TRACK FOR MAINLINE

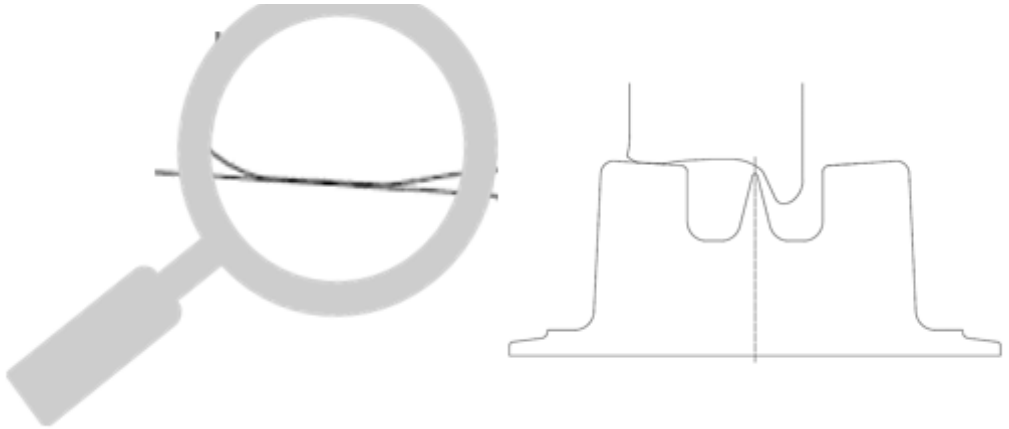
CROSSING

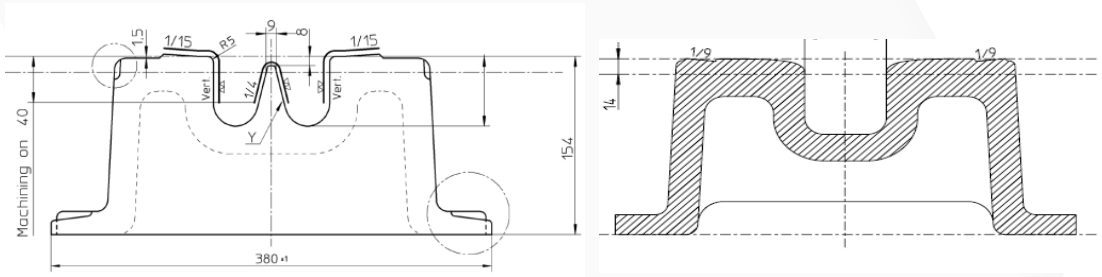
- The central block in 12-14% Manganese (Mn) steel is casted
- Mn steel: 200 HB / 550 HB after hammering
- 4 connecting rails are electrically welded to the block → Timetallic Process
- Modern software tools make it possible to optimize the passage of the wheels and minimize impact







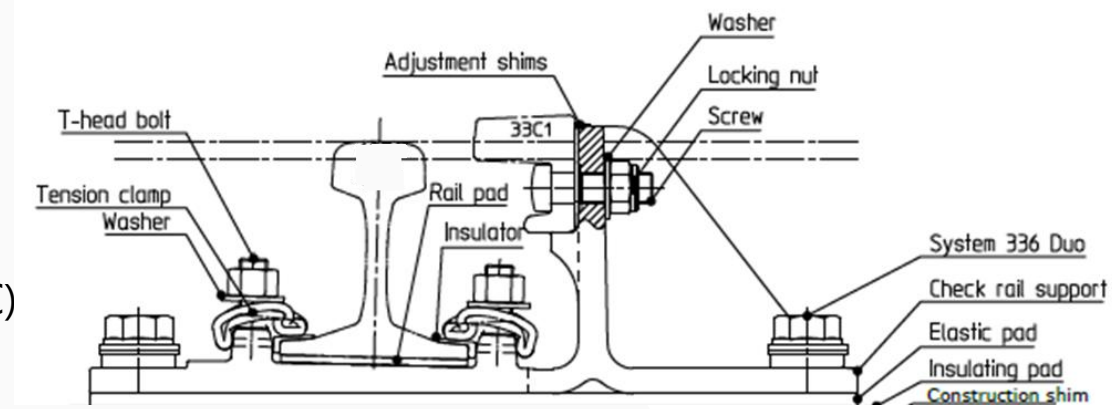




TRACK FOR MAINLINE

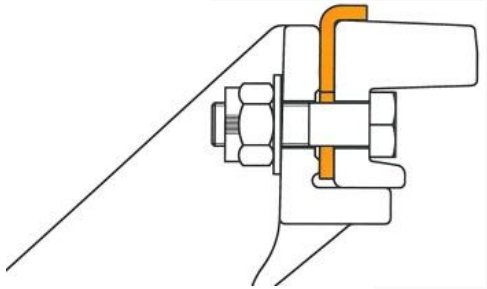
CROSSING

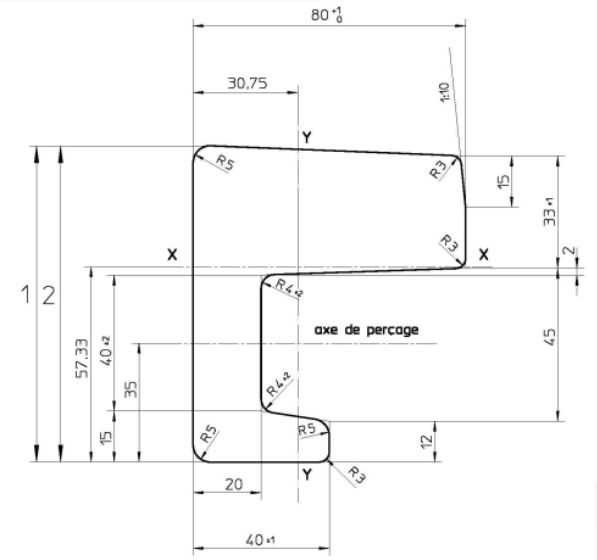
- Check rail supports are casted and guarantee the protection of the crossing nose
- The check rails are positioned vertically (15mm superelevation → TBC) and horizontally by check rail supports
- Rail profile 33C1 steel grade R260 or 320Cr according to European standard EN 13674-3
- The check rail support is fixed onto the bearer with 336 DUO system



Material: EN GS 500-7 or GS 400-18LT
Technical specifications: EN 1563

Setting by shims
A shim adjustment system restores the safety dimensions.
Adjustment by shims: The interposition of a shim between the check rail and the bearer is used to set the flangeway according to the wheel profile.





1. 93 ± 1 à l'intersection des faces
2. 92,805 hauteur du contre-rail

Surface de la section *Cross-sectional area*	42,02 cm²	Moment d'inertie axe y-y *Moment of inertia y-y axis*	218,8 cm⁴
Masse par mètre *Mass per metre*	32,99 kg/m	Module d'inertie axe y-y (i/v) *Section modulus y-y axis (i/v)*	G / L = 71,2 cm³ D / R = 44,4 cm³
Moment d'inertie axe x-x (i/v) *Moment of inertia x-x axis (i/v)*	297,0 cm⁴		

Plan suivant norme / *Drawing according to standard* NF EN 13674-3+A1 (2010)

33 C1	*UIC33 - U69*	6 420 2028

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6.4

TRACK FOR DEPOT

HANOI METRO

T2

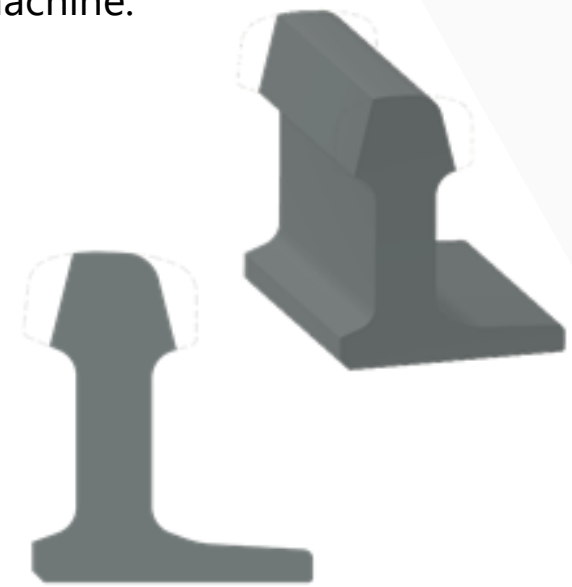
TRACK FOR MAINLINE

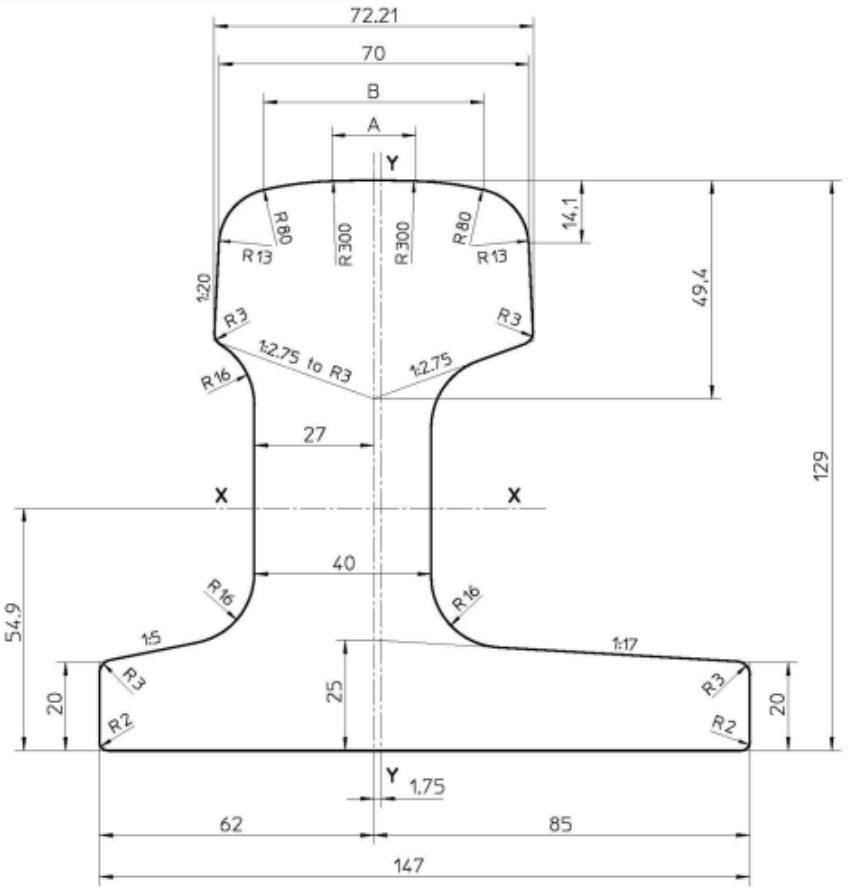
TONGUE FOR MAINLINE

- The elastic tongue without elastic chamber is made of 54E1A1 asymmetrical rail.
- The machining of the rolling surface takes in account the 1/40 canted laying and is forged on the heel to the 54E1 profile.
- The forging length of the heel is 450mm and the length of the transition area of the 2 rail profiles is 150 mm (Total length of forged area = 600mm maximum)
- The machining is made with a milling machine.
- The rail is fully treated.

Material: steel quality R260

Technical Specifications: EN 13674-2





Surface de la section *Cross-sectional area*	87,83 cm²	Moment d'inertie axe y-y *Moment of inertia y-y axis*	767,6 cm⁴
Masse par mètre *Mass per metre*	68,95 kg/m	Module d'inertie axe y-y (i/v) *Section modulus y-y axis (i/v)*	G / L = 120,4 cm³ D / R = 92,2 cm³
Moment d'inertie axe x-x (i/v) *Moment of inertia x-x axis (i/v)*	1544,0 cm⁴	Dimension indicative *Indicative dimensions*	A = 20,025 mm B = 49,727 mm

Plan suivant norme / *Drawing according to standard* NF EN 13674-2+A1 (2010)

54E1A1	*UIC54B - A69*	6 420 2024

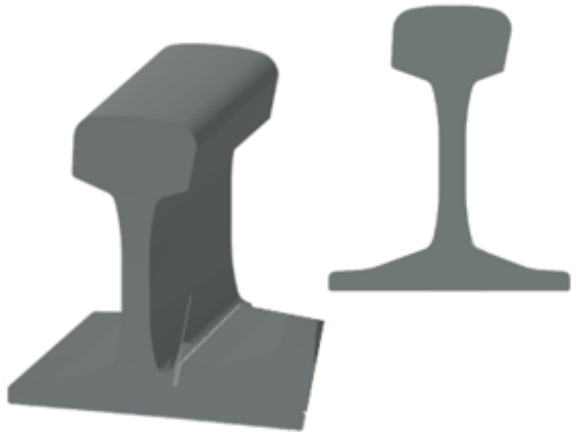
TRACK FOR MAINLINE

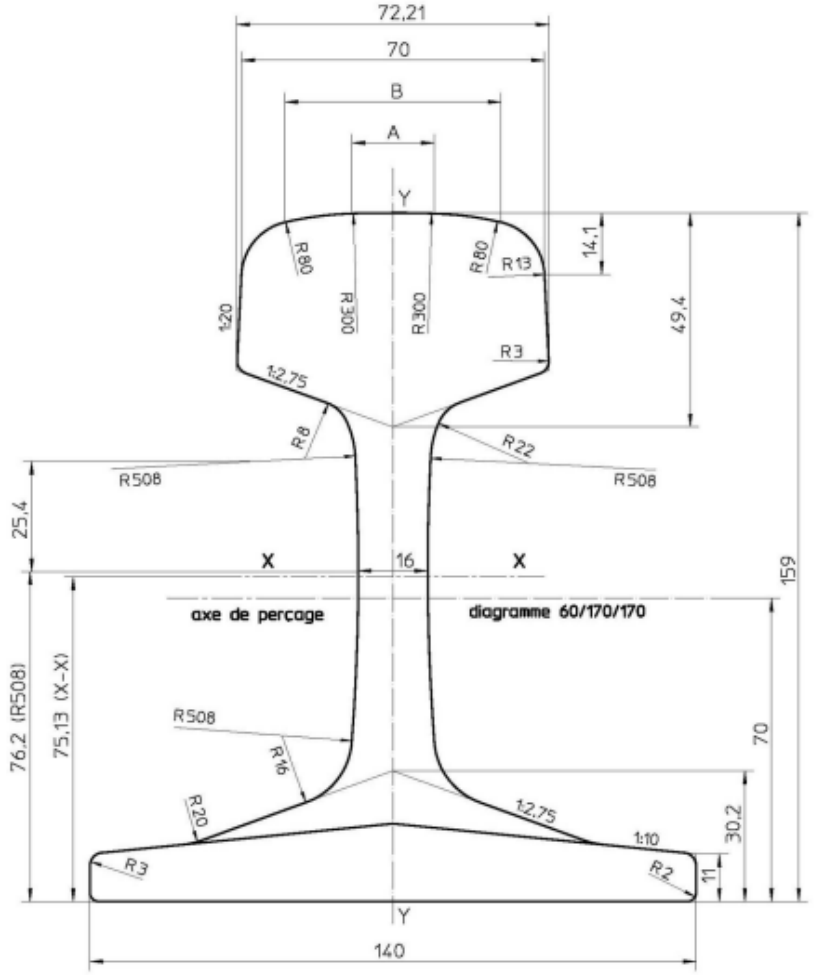
TONGUE FOR MAINLINE

- Rails 60E1 fully treated.
- The laying of the stock rail is canted 1/40. The machining is made on a milling machine.
- The web of the stock rail is drilled to fit the stops, Anti-Creep monitoring device, ALD, and the marking of the switch toe.

Material: steel quality R350HT

Technical Specifications: EN 13674-1





Surface de la section *Cross-sectional area*	69.77 cm²	Moment d'inertie axe y-y *Moment of inertia y-y axis*	419.2 cm⁴
Masse par mètre *Mass per metre*	54.77 kg/m	Module d'inertie axe y-y (i/v) *Section modulus y-y axis (i/v)*	59.9 cm³
Moment d'inertie axe x-x (i/v) *Moment of inertia x-x axis (i/v)*	2337.9 cm⁴	Dimension indicative *Indicative dimensions*	A = 20.024 mm B = 49.727 mm

Plan suivant norme / *Drawing according to standard* NF EN 13674-1+A1 (2017)

54 E1	*UIC 54*	6 420 2014

TRACK FOR MAINLINE

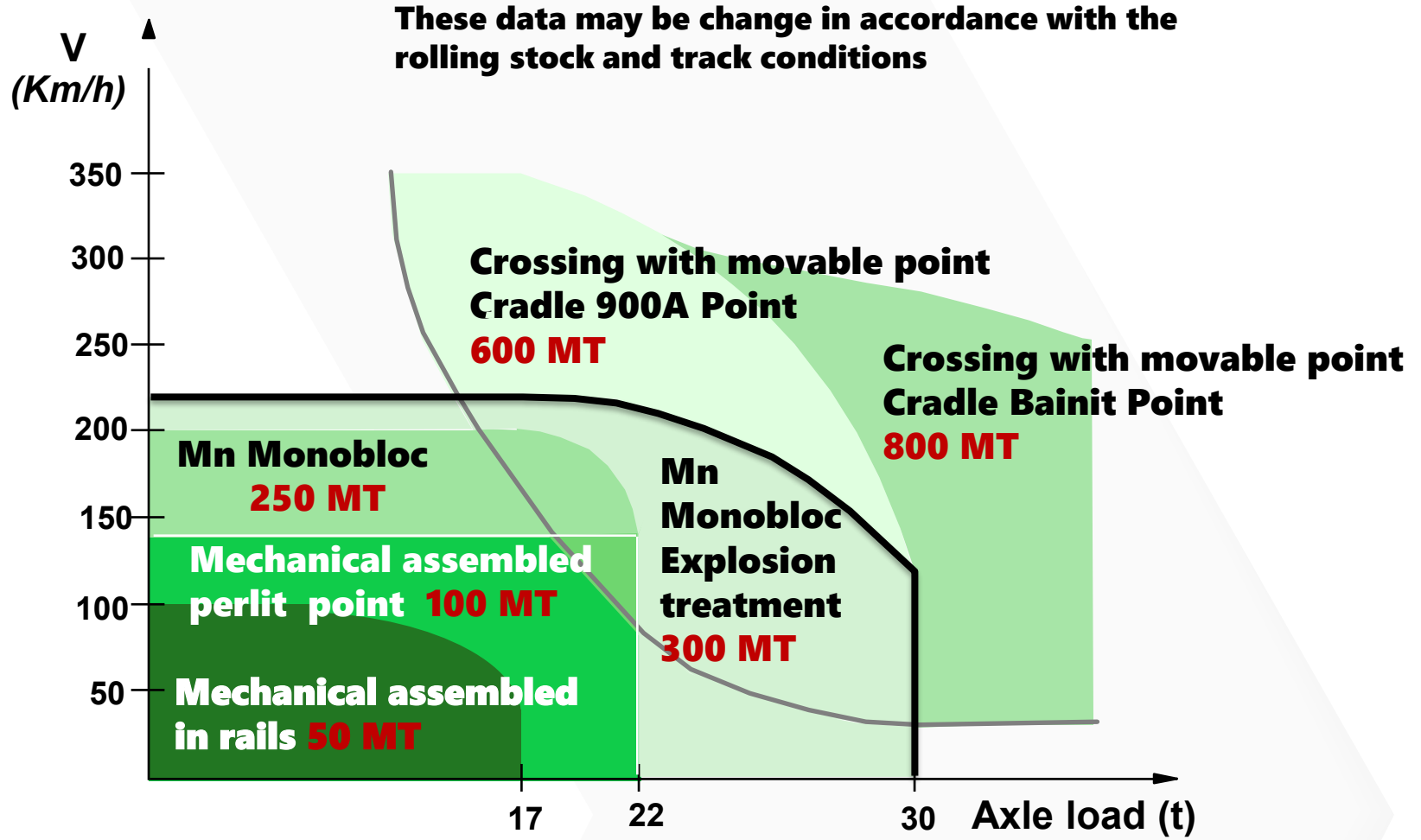
CROSSING

Traffic density data :

- Metro is a mass rapid transit
- Traffic assumption : Depot
- Annual traffic : Depot

Vossloh Advise :

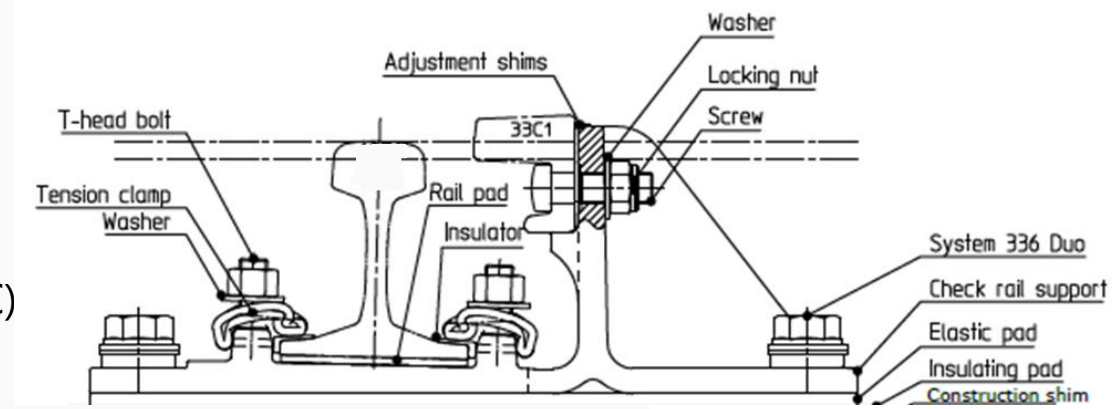
- Mn Monobloc crossing



TRACK FOR MAINLINE

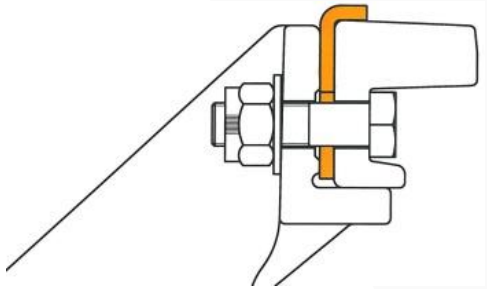
CROSSING

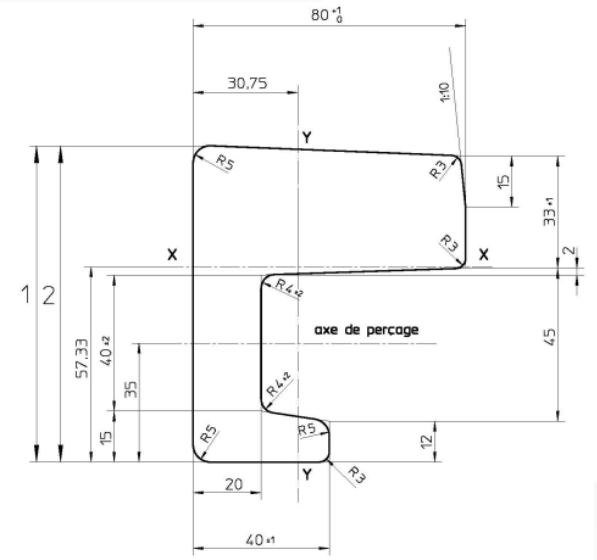
- Check rail supports are casted and guarantee the protection of the crossing nose
- The check rails are positioned vertically (15mm superelevation → TBC) and horizontally by check rail supports
- Rail profile 33C1 steel grade R260 or 320Cr according to European standard EN 13674-3
- The check rail support is fixed onto the bearer with 336 DUO system



Material: EN GS 500-7 or GS 400-18LT
Technical specifications: EN 1563

Setting by shims
A shim adjustment system restores the safety dimensions.
Adjustment by shims: The interposition of a shim between the check rail and the bearer is used to set the flangeway according to the wheel profile.





1. 93 ± 1 à l'intersection des faces
2. 92,805 hauteur du contre-rail

Surface de la section *Cross-sectional area*	42,02 cm²	Moment d'inertie axe y-y *Moment of inertia y-y axis*	218,8 cm⁴
Masse par mètre *Mass per metre*	32,99 kg/m	Module d'inertie axe y-y (i/v) *Section modulus y-y axis (i/v)*	G / L = 71,2 cm³ D / R = 44,4 cm³
Moment d'inertie axe x-x (i/v) *Moment of inertia x-x axis (i/v)*	297,0 cm⁴		

Plan suivant norme / *Drawing according to standard* NF EN 13674-3+A1 (2010)

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QUESTIONS / ANSWERS
DISCUSSIONS

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THANK YOU FOR YOUR ATTENTION