# RAILWAYS

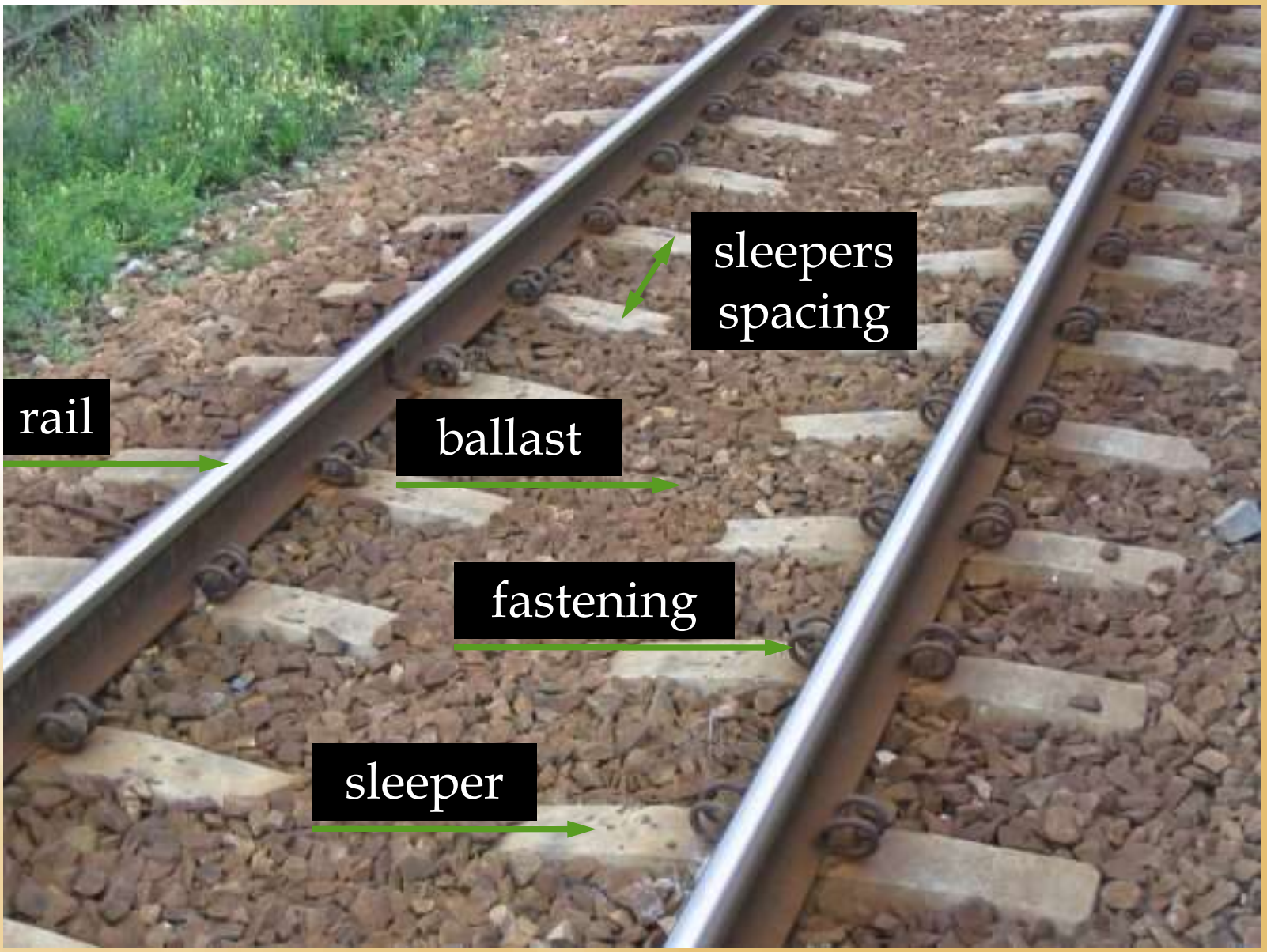
# Railway technology

1. Technology of building a new line
2. Track geometry measurement
3. Maintenance and auxiliary works
4. Existing lines modernization

PhD CE Jarosław Zwolski



# Track elements



# Rails

- Profile types:
  S60, S49, for tram Ri-60N, UIC60, UIC54 (European countries).
- Cast steel with increased carbon content (up to 0,6-0,7%) and manganese (up to 2%), sometimes thermal processed, with yeld stress $R_e$=700 MPa and hardness over 300 HB:
  - St90 (strength $R_m$=880 MPa)
  - St110 (strength $R_m$=1100 MPa)
- Typical rolling length: 25 m (S60) and 30 m (S49)








# Types of fastening

- Direct,
- Classic (K-type),
- Elastic (SB-3, Skl, Nabla, Pandroll-Fastclip, etc.)












# Sleepers types

Depending on material:

- wooden,
- concrete,
- concrete-steel,
- steel
- plastic/rubber

Concrete sleepers depending on reinforcement type:

- reinforced concrete,
- prestressed concrete.

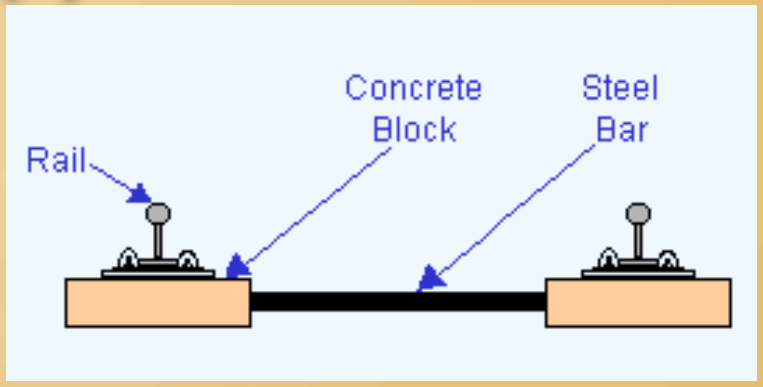
Depending on shape:

- beam,
- beam - block,
- slab.

# Sleepers types












# Track classes

| Track class | Allowable maximum speed [km/h] | Allowable locomotive axle load [kN] | Allowable car axle load [kN] | Traffic intensity [Tg/year] |
|---|---|---|---|---|
| 0 | 200 | 221 | 140 | up to 25 |
| 1 | 100<br>120<br>140<br>160 | 221<br>210<br>210<br>205 | 221<br>205<br>190<br>140 | unspecified |
| 2 | 80<br>100<br>120 | 221<br>210<br>205 | 221<br>205<br>190 | 16-25 |
| 3 | 70<br>80 | 221<br>210 | 221<br>205 | 9-15 |
| 4 | 60<br>70 | 221<br>210 | 221<br>205 | 4-8 |
| 5 | 30<br>40 | 221<br>210 | 221<br>205 | less than 3 |

## Example of a track technical standard

| Variant | Rails | Sleepers type | Sleepers spacing [m] | Fastening type | Minimum ballast thickness [m] |
|---|---|---|---|---|---|
| 0.1 | UIC60 new, for v>200 km/h | PS-93, PS-94 | 0,60 | SB | 0,35 |

# Building of a new track (1)



Ground works – shaping and compaction



Shaping the slopes (Upper ditch)



Slope surface protection



Prepared trackway



Laying down the geotextiles



Laying down the waterproof membrane (in case of water sensitive soil)

source: www.transportszynowy.pl

# Building of a new track (2)



Subballast reinforcement (optional)



Protective layer (mixture) on the geogrid



Protective layer (mixture) on the geotextile



Grader for profiling the protective layer




Compaction of the protective layer



Prepared trackway

source: www.transportszynowy.pl

# Building of a new track (3)



Preparation of ballast



Profiling of ballast




Ballast compaction



Laying down temporary rails for gantry cranes



Sleepers transportation by the moving gantry cranes



Sleepers placing and spacing by the gantry cranes

# Building of a new track (4)



Laying down the rails on the final position



The laid rails



Turnouts assembling



Rails welding



Gringing of the joints



Assembling of the spring clamps – fastening of the track ladder

source: www.transportszynowy.pl

# Building of a new track (5)



Pouring of ballast in excess



Track tamping



Ballast profilling



Finished track

source: www.transportszynowy.pl

# Common works on track

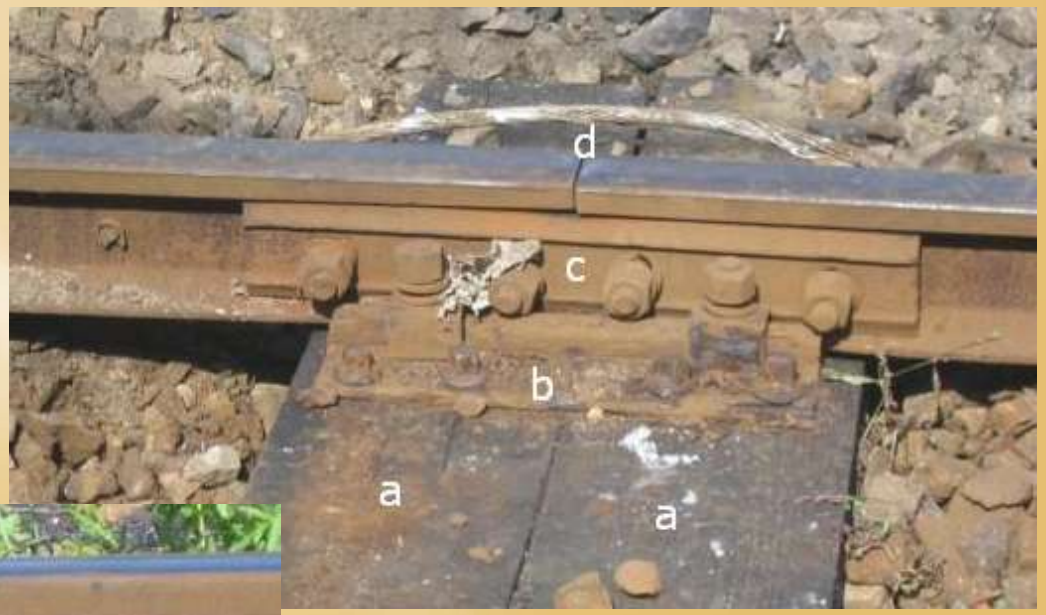
1) Rail welding (flash-butt, thermite)
2) Rail inspection & geometry measurement
3) Rail grinding

4) Ballast profiling
5) Ballast stabilisation
6) Ballast cleaning
7) Track inspection (ballast and subballast)

8) Track and turnouts tamping
9) Track replacement
10) Snow removal
11) Catenary inspection and maintenance

# Common joints of rails

Supported joint
a – wooden sleepers,
b – double steel pad,
c – 4-hole fishplate,
d – a gap between adjacent rails







Unsupported joint
1 – 4-hole fishplate,
2 – bolts and nuts,
3 – a gap between adjacent rails,
4 – single steel pad.

source: www.transportszynowy.pl

# Thermite welding

Thermite – a mixture of powdered aluminium and iron oxide.
In the thermite reaction aluminium rapidly reduces oxides of metal and produces energy with one of the highest temperature in industrial processes (around 3000 °C and with special additives even 3800 °C). As the products of the reaction aluminium oxide and liquid iron is obtained. If thermite is made of iron oxide for the maximum effectiveness it should contain 25,3% of aluminium and 74,7% of iron oxide. The reaction looks like that:

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe; \quad \Delta H = -851{,}5\ kJ/mol$$

but if thermite is made with use of $FeO \cdot Fe_2O_3$, the optimal proportions are 23,7% of aluminium and 76,3% of the oxide. The reaction runs according to the formula:

$$3Fe_3O_4 + 8Al \rightarrow 4Al_2O_3 + 9Fe; \quad \Delta H = -3347{,}6\ kJ/mol$$

# Thermite welding



Prepared rail



Placed form



Heating of the rail



Lightening of
the thermite mixture



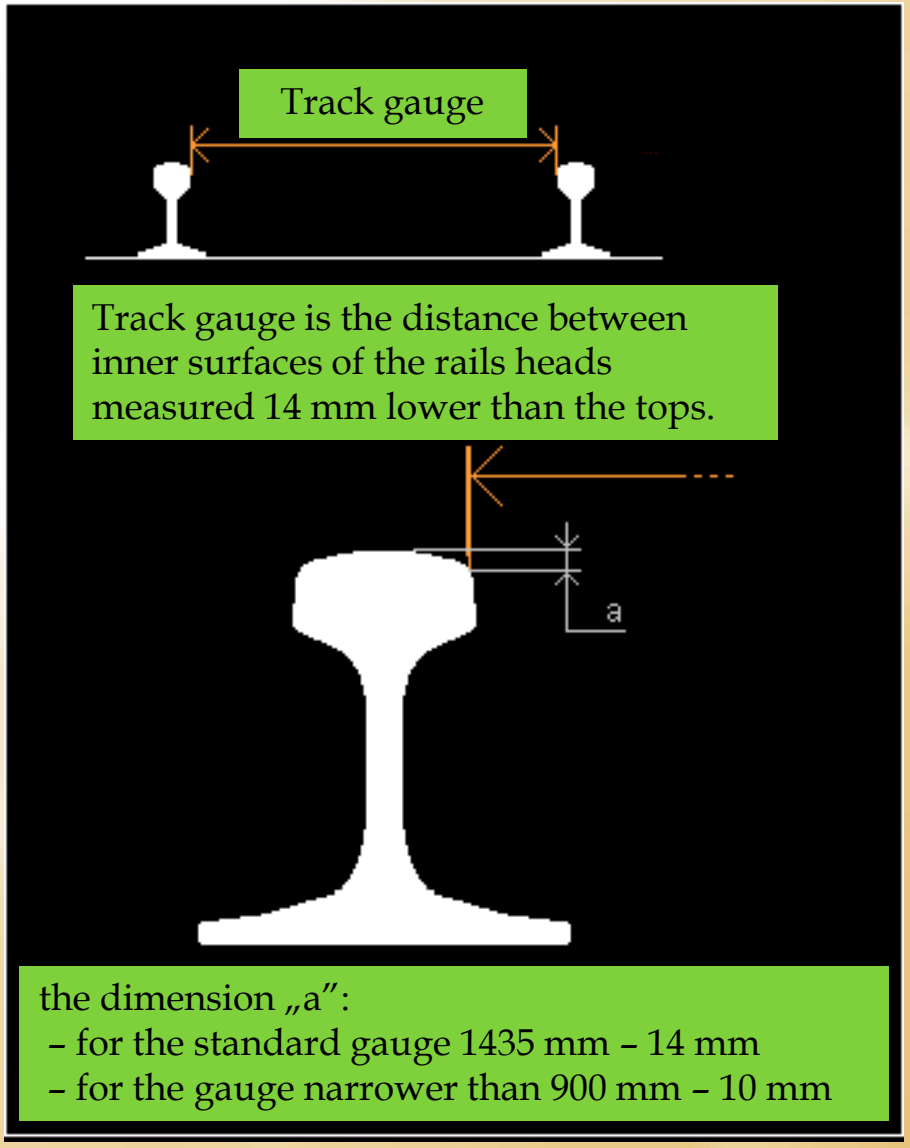
Melting of the binder



Grinding of the joint

source: www.transportszynowy.pl

# Track gauge



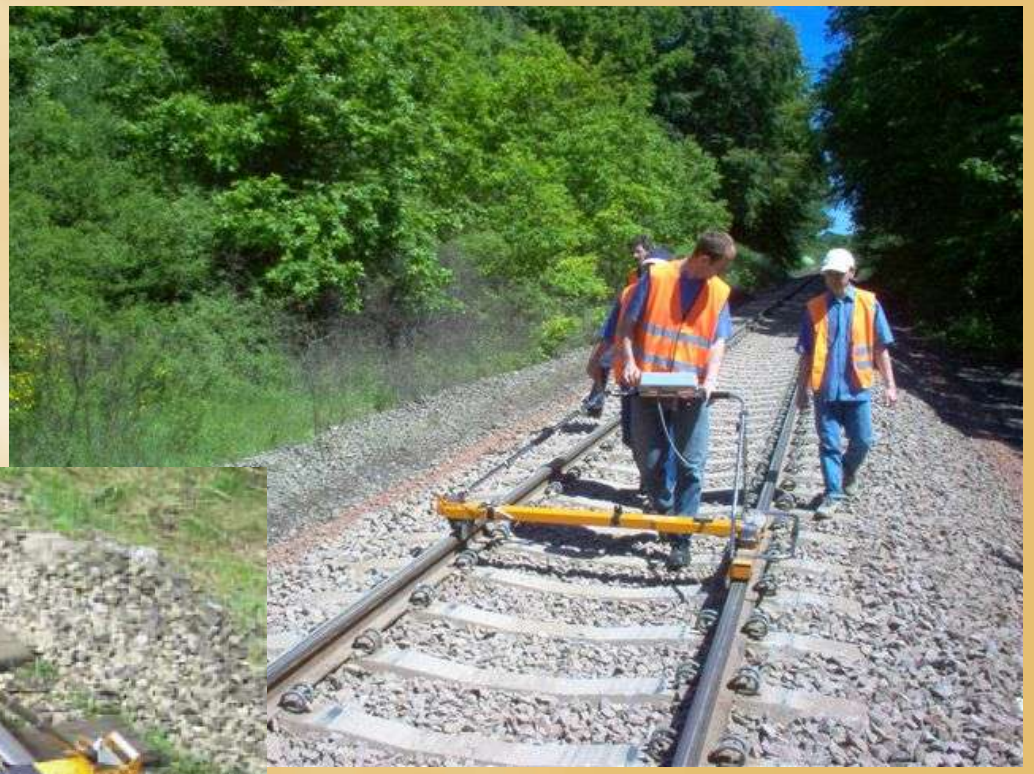

Allowable tollerances of the gauge on straight sections of track are + 10mm and - 3mm.

źródło: www.transportszynowy.pl

# Track geometry control

Measurement trolley with laser device and automatic data recording.





Measurement

# Measuring (recording) cars







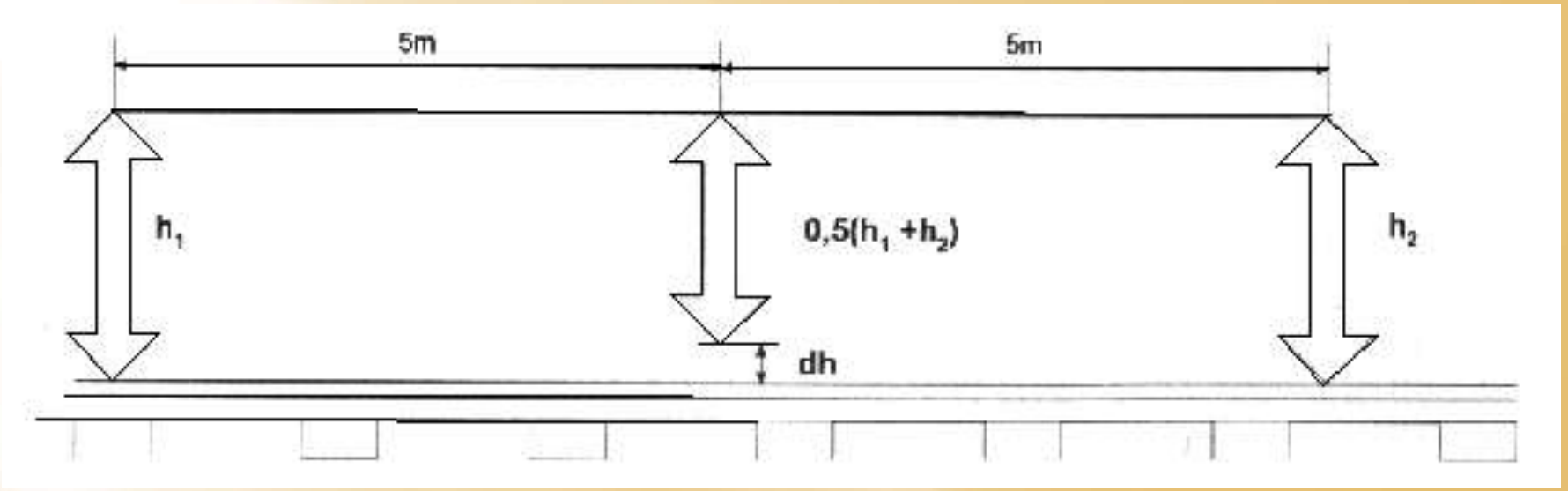
Car DP-523.10 for ultrasound detection of rails defects




Car EM 120 for geometry measurement:

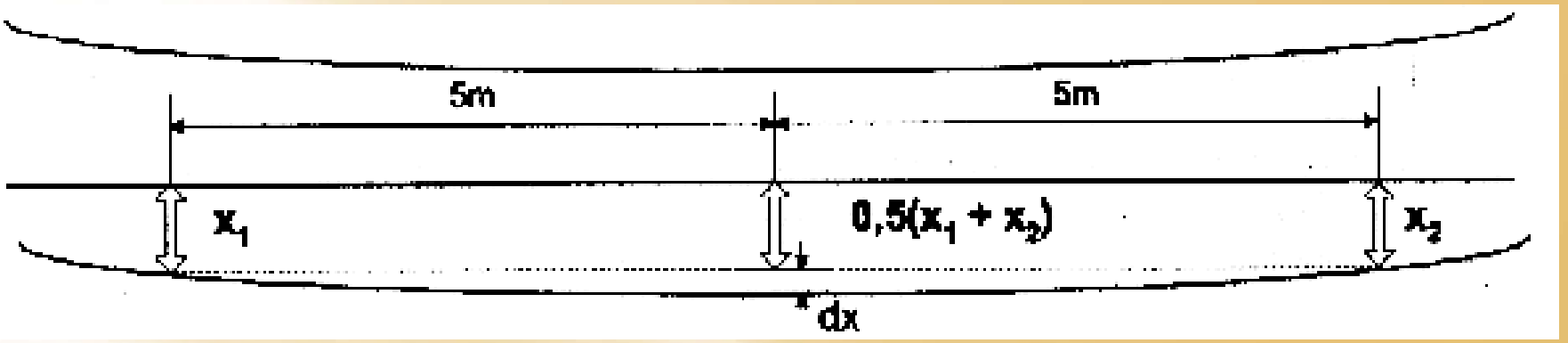
- ❑ vertical roughness,
- ❑ horizontal roughness,
- ❑ cant,
- ❑ twist,
- ❑ track gauge.

# Vertical plane inequalities



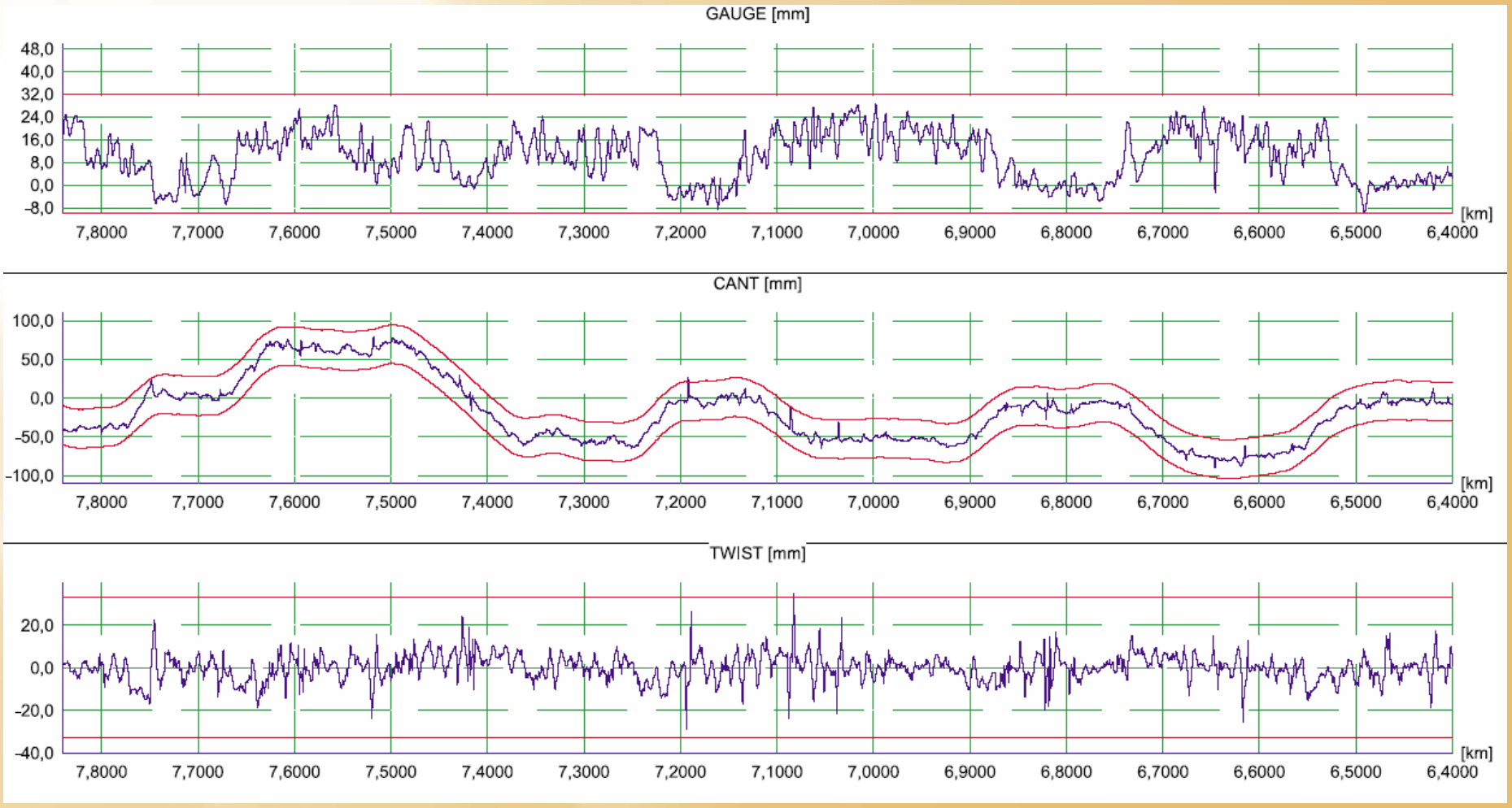

1) Cant - difference in the height of rail heads in one cross section.
2) Twist – difference in cant on the base length of 5 m.
3) Vertical roughness – vertical deviation of the rail from a base line made by points of tangency of 2 wheels with the rail (base distance equals to 10 m). It is measured independently for both rails.

# Horizontal plane inequalities



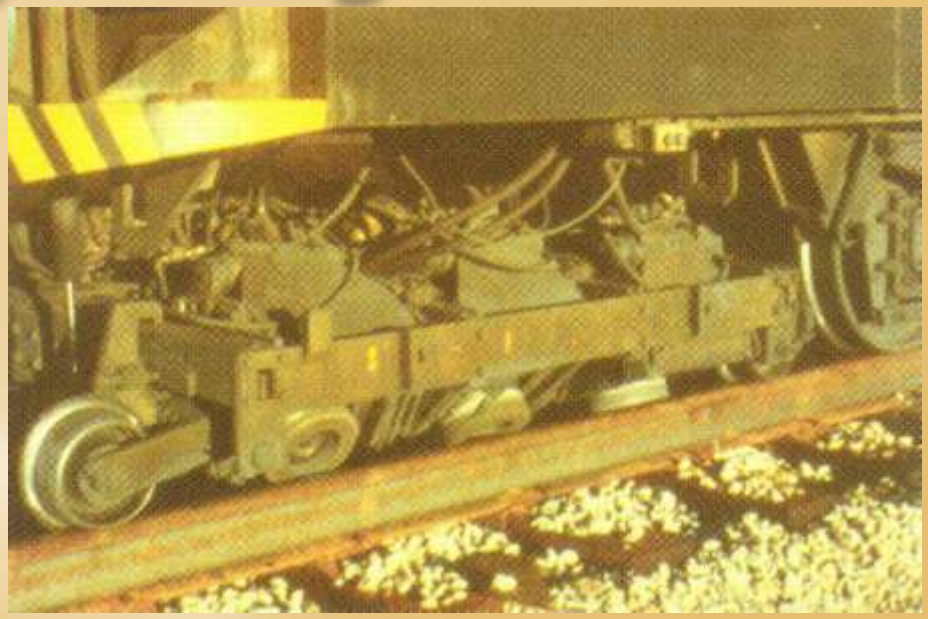

1) Track gauge – the distance between the inner surfaces of the head rails measured 14 mm lower than the head tops.
2) Track gauge derivative – a change of the track gauge on the base of 1.0 m (it is a supplementary parameter of track geometry).
3) Horizontal roughness – horizontal deviation of the rail head from a base line (10 m long) measured independently for both rails.

# Example of measurement result



# Rails grinding

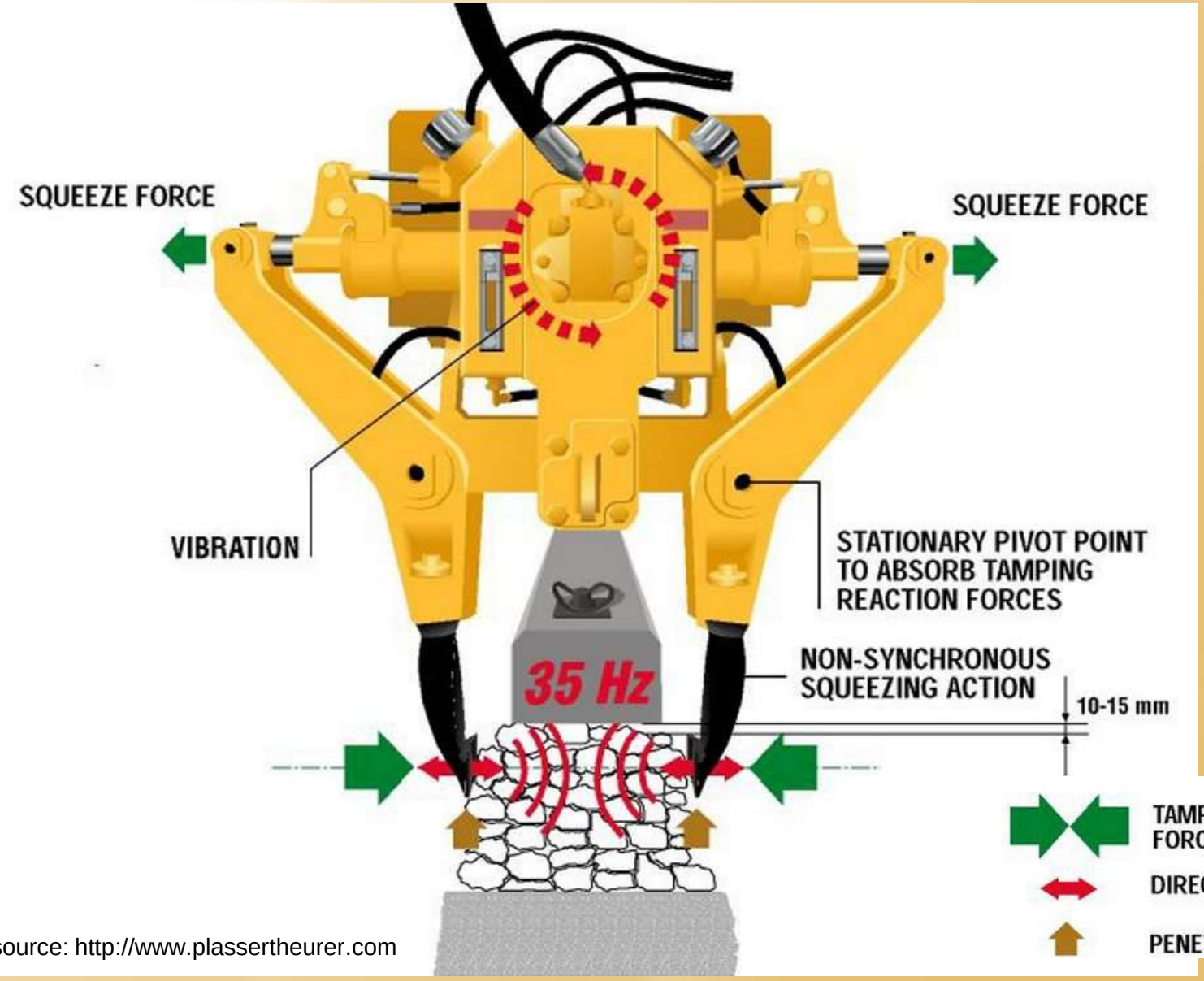








# Track tamping - principle




source: http://www.plassertheurer.com

# Track tamping



Lifting the track ladder

source: www.transportszynowy.pl

Hydraulic mechanism
with tines



Geometry controll



Movie1

Movie2

# Tamping machines



Tamping machine PR 07




Tamping machine PT 09 32




Universal tamping machine Unimat
by Plasser & Theurer



Tamping machine MD 07

# Snow removal



Plough 411S-38



Rotary plough KSF



Rotary plough Henschel

MOVIE



Heavy plough from Canada

# UNIMOG vehicles



UNIMOG Mower



UNIMOG Rescue Car

Other summer service:

- Sweeper
- Mower (vegetation remover)
- Cleaning device
- Rescue car
- Transport and other purpose car

Winter service:

- Snow plough
- Snow blower
- Salt spreader

MOVIE1

MOVIE2

# Catenary inspection & maintenance





MOVIE1

MOVIE2

# Modernization and repair

Condition reasons for repair or modernization:

- Weak subballast (low bearing capacity)
- Change of water conditions in the formation and in the dewatering system
- Landslides
- Deterioration of the pavement elements: sleepers, fastening elements, rails wear
- Ballast wear (blunt edges) and contamination
- Mixing of the subballast and ballast layers, mud splashes on ballast

Usability reasons for modernization:

- Speed limitations
- Clearance limitations
- Axle load limitations
- Other reasons (obsolete technology of signalling and control, incompatibility of control devices etc.)

These two movies are recommended to watch:
http://www.youtube.com/watch?v=iF-3ditSCIk&feature=related
http://www.youtube.com/watch?v=ixfIOr6eycU&feature=related