RAILWAYS

Railway technology

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

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Track elements

- rail
- ballast
- fastening
- sleeper
- sleepers spacing
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 yield 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

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

### Example of a track technical standard

<table>
<thead>
<tr>
<th>Variant</th>
<th>Rails</th>
<th>Sleepers type</th>
<th>Sleepers spacing [m]</th>
<th>Fastening type</th>
<th>Minimum ballast thickness [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>UIC60 new, for v＞200 km/h</td>
<td>PS-93, PS-94</td>
<td>0.60</td>
<td>SB</td>
<td>0.35</td>
</tr>
</tbody>
</table>
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
Grining 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 profiling
- Finished track

source: www.transportszynowy.pl
Common works on track

1) Rail welding (flash-but, 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.transportszynowoy.pl
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:

$$\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}; \quad \Delta H = -851,5 \, \text{kJ/mol}$$

but if thermite is made with use of FeO·Fe$_2$O$_3$, the optimal proportions are 23,7% of aluminium and 76,3% of the oxide. The reaction runs according to the formula:

$$3\text{Fe}_3\text{O}_4 + 8\text{Al} \rightarrow 4\text{Al}_2\text{O}_3 + 9\text{Fe}; \quad \Delta H = -3347,6 \, \text{kJ/mol}$$
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
Allowable tolerances of the gauge on straight sections of track are +10mm and -3mm.

Track gauge is the distance between inner surfaces of the rails heads measured 14 mm lower than the tops.

the dimension „a“:
- for the standard gauge 1435 mm – 14 mm
- for the gauge narrower than 900 mm – 10 mm
Track geometry control

Measurement trolley with laser device and automatic data recording.
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.
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.
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
Track tamping - principle

- Squeeze force
- Vibration
- 35 Hz
- Stationary pivot point to absorb tamping reaction forces
- Non-synchronous squeezing action
- 10-15 mm
- Tamping reaction force
- Directional vibration
- Penetrating reaction force

Source: http://www.plassertheurer.com
Track tamping

Lifting the track ladder
source: www.transportszynowy.pl

Hydraulic mechanism with tines

Geometry control

Movie1

Movie2
Snow removal

Plough 411S-38

Rotary plough KSF

Rotary plough Henschel

Heavy plough from Canada

MOVIE
UNIMOG vehicles

Other summer service:
- Sweeper
- Mower (vegetation remover)
- Cleaning device
- Rescue car
- Transport and other purpose car

UNIMOG Rescue Car

Winter service:
- Snow plough
- Snow blower
- Salt spreader

UNIMOG Mower
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