Modification of the electrical traction system on railway lines Moravice – Rijeka - Šapjane, Škrljevo – Bakar and Sušak Pećine – Rijeka Brajdica (METS project)

PREPARED BY: Josip Pavleka, B.Sc.E.E.
ELECTRIFIED RAILWAY LINES IN CROATIA UNTIL 13 DECEMBER 2012
STATUS PRIOR TO THE BEGINNING OF PROJECT REALIZATION

- SINGLE-TRACK RAILWAY LINE WAS PUT IN OPERATION IN 1873
- THE MOST CHALLENGING PARTS OF THE MOUNTAIN RAILWAY LINE ARE FROM RIJEKA TO LOKVE (52 km) – 25 mm/m
- TWO THIRDS OF THE RAILWAY LINE MORAVICE – RIJEKA ARE IN CURVES, THE SMALLEST RADII ARE WITHIN THE RANGE 250-300 m
- IN 1987 3 kV DC SYSTEM WAS REPLACED BY THE 25 kV, 50 HZ SYSTEM
- RAILWAY LINE RIJEKA – ŠAPJANE – STATE BORDER WAS ELECTRIFIED IN 1938
- EQUIPMENT IS 48-70 YEARS OLD
- POWER SUPPLY LINES, WHICH THE CROATIAN NATIONAL POWER UTILITY COMPANY (HEP) WILL STOP MAINTAINING (IT ABANDONS THAT VOLTAGE LEVEL) ARE OF 35 kV RATED VOLTAGE
RAILWAY LINE PROFILE
REASONS FOR THE MODIFICATION OF THE ELECTRICAL TRACTION SYSTEM – BUSINESS GOALS (1)

- REALIZATION OF THE SINGLE ELECTRICAL TRACTION SYSTEM ON THE HŽI NETWORK
- SIGNIFICANT INCREASE OF THE RAILWAY LINE TRANSPORT CAPACITY (TO 11 million NT)
- FIXED AND MOBILE FACILITIES MAINTENANCE COSTS ARE SMALLER WITH THE ALTERNATING THAN WITH THE DIRECT CURRENT SYSTEM
- DC SYSTEM FACILITIES WERE ENTIRELY OBSOLETE. SPARE PARTS WERE NOT AVAILABLE. REVITALIZATION IS ABSOLUTELY NECESSARY. ITS PRICE WOULD AMOUNT TO ca. 60% OF THE VALUE OF THE ENTIRELY NEW SYSTEM.
- ELECTRICAL LOCOMOTIVES OF THE 1061 SERIES ARE ON THE AVERAGE OVER 40 YEARS OLD; THE LATEST NEW LOCOMOTIVE WAS PURCHASED IN 1969; REVITALIZATION OF THE TRACTION UNITS AND PURCHASE OF THE NEW ONES IS ABSOLUTELY NECESSARY.
- HEP IS ABANDONING THE USE AND THE MAINTENANCE OF THE 35 kV POWER LINE
REASONS FOR MODIFICATION OF THE ELECTRICAL TRACTION SYSTEM– BUSINESS GOALS (2)

- NEW, ECONOMICALLY JUSTIFIED TECHNICAL SOLUTIONS ARE TO BE INTRODUCED: COMPENSATED OVERHEAD LINE EQUIPMENT INSTEAD OF THE SEMI-COMPENSATED, REMOTE CONTROL SYSTEM, OVERHEAD LINE EQUIPMENT WITH AN ADDITIONAL CURRENT RETURN CIRCUIT. FASTER REPAIR OF BREAKDOWNS

- SMALLER STAFF NUMBER (IMPROVEMENT OF THE WORKING RATIO)

- SMALLER ELECTRICITY COSTS, IN VIEW OF THE FACT THAT THE ELECTRICITY UNIT PRICE WITH THE DIRECT CURRENT SYSTEM IS BY ca. 70% HIGHER
DIMENSIONING OF THE FACILITIES

- ACCORDING TO THE MAXIMUM TRAIN TIMETABLE GRAPH
- ACCORDING TO THE DISTRIBUTION OF THE TRANSFORMER STATIONS AND THE POWER LINES OF THE ELECTRIC POWER ECONOMIC SYSTEM
- ACCORDING TO THE ELEMENTS OF THE SIGNALING AND INTERLOCKING SUBSYSTEM
MAXIMUM TRAIN TIMETABLE GRAPH
CONNECTION OF ETS TO THE HEP NETWORK
SIMULATION OF THE TRAIN WORKING AND REACTIVE POWER CALCULATION 1500 t = f (TRAIN SPEED, RAILWAY LINE PARAMETERS)
LOCATIONS OF ELECTRIC TRACTION SUBSTATIONS, SECTIONING FACILITIES AND NEUTRAL SECTIONS

ETS Moravice  ETS Delnice  ETS Vrata  ETS Plase  ETS Sušak  ETS Matulji
**SOLUTION OF ASYMMETRY IN THE ELECTRICITY ECONOMIC SYSTEM (STUDY BY THE FACULTY OF ELECTRICAL ENGINEERING)**

<table>
<thead>
<tr>
<th>EVP 110/25 kV</th>
<th>Priklučak na faze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moravice</td>
<td>4 i 8</td>
</tr>
<tr>
<td>Delnice</td>
<td>4 i 8</td>
</tr>
<tr>
<td>Vrata</td>
<td>4 i 8</td>
</tr>
<tr>
<td>Plase</td>
<td>4 i 0</td>
</tr>
<tr>
<td>Sušak</td>
<td>4 i 0</td>
</tr>
<tr>
<td>Matulji</td>
<td>4 i 0</td>
</tr>
</tbody>
</table>

Tablica 8.1. Prijedlog izvedbe priključka pojedinih EVP-a na prijenosnu mrežu 110 kV

Na slici 8.1. je grafički prikazano priključenje EVP-a na različite faze 110 kV mreže uz nazivni napon 25 kV na mjestu sučeljavanja.

Slika 8.1. Priklučenje EVP-a na različite faze 110 kV mreže uz nazivni napon 25 kV na mjestu sučeljavanja.
ETS – INVESTOR- HŽI, HEP-TRANSMISSION SYSTEM OPERATOR AND HEP DISTRIBUTION SYSTEM OPERATOR
TECHNICAL SOLUTIONS OF RELAY PROTECTION
FACILITIES WITHIN THE METS

- 110KV POWER TRANSMISSION LINES AND FIELDS
- ELECTRICAL TRACTION SUBSTATIONS (DELNICE, VRATA, PLASE, SUŠAK, MATULJI)
- SECTIONING FACILITIES (SKRAD, LOKVE, DELNICE, SV. KUZAM, RIJEKA)
- OVERHEAD LINE EQUIPMENT OF THE OPEN RAILWAY LINE AND THE THROUGH TRACKS 135,4 km
- BUILDING OF ORGANIZATION MAINTENANCE UNITS IN DELNICE
- REMOTE CONTROL CENTRE
- REMOTE AND LOCAL CONTROL
- 10/0,4 kV TRANSFORMER STATIONS AND 10 kV POWER LINES
- CONSTRUCTION AND RECONSTRUCTION OF THE TELECOMMUNICATION SYSTEM
- ADAPTATION OF THE SIGNALLING AND INTERRAILWAY LINELOCKING EQUIPMENT
- OPTICAL SYSTEMS
DYNAMICS OF WORKS, CONSTRUCTION ORGANIZATION, PROJECT MANAGEMENT

ISEV - TEHNOLOŠKI PROJEKT
- Tehnologija građenja -

PRILOG 6.2

FUNKCIONALNO - TEHNOLOŠKE ETAPE
ORGANIZATION OF MAIN WORKS ON THE OVERHEAD LINE EQUIPMENT

- Within the same railway line, closure works were performed on several sites at different interstation distances, thus considerably reducing the required railway line closures.
- Permanent railway line closures in duration of 5-6 hours during which the works on the open railway line and on the entry and exit sets of switches were performed.
- Works on the overhead line equipment in stations were performed within the regular railway line maintenance periods.
- Works not directly related to the railway line (ETS, PSN, DV, DVP) were performed without the closure.
- After each particular railway line closure the train traction was performed in the same way as prior to the closure (3 kV DC voltage was switched on), and the trains operated in line with the train schedule.
RECONSTRUCTION OF THE CATHODIC PROTECTION OF JANAF AND PLINACRO FACILITIES
PROTECTION OF THE HT LINES FROM THE ELECTRICAL TRACTION IMPACT

Raspadjela inducirana napona po duljini kraka prikazana je slicom 1.37.

Slika 1.37. Inducirani napon po duljini na kraku RG 51 Bakar – Sv. Kuzam

1.4.9.3 RG 51 Bakar – Sušak
ADAPTATION OF THE TUNNELS TO THE REQUIREMENTS OF THE 25 kV, 50 Hz OVERHEAD LINE EQUIPMENT

- IT SHOULD BE PROVIDED FOR THE MINIMUM CATENARY HEIGHT OF 5100 mm
- IT SHOULD BE PROVIDED FOR THE SAFETY DISTANCES FOR THE 25 kV CURRENT SYSTEM IN LINE WITH THE HRN EN 50119
- BALLAST PRISM WITH THE MINIMUM 30 CM GRAVEL UNDER THE LOWER SLEEPER EDGE UNDER THE CANTED RAIL SHOULD BE PROVIDED FOR
REPLACEMENT OF THE WOODEN SLEEPERS BY THE STEEL HOLLOW SLEEPERS

HEIGHT (h) OF AT LEAST 100 mm

WIDTH ON THE LOWER SURFACE (B) OF AT LEAST 250 mm

WIDTH ON THE UPPER SURFACE (A) OF AT LEAST 130 mm

THICKNESS OF THE SLEEPER WALL (D) OF AT LEAST 9 mm

SLEEPER LENGTH OF 260 cm

(Stanard HRN EN ISO 6305-3)
REPLACEMENT OF THE WOODEN SLEEPERS BY THE STEEL HOLLOW SLEEPERS

This solution, i.e. the difference in the height of a wooden and a steel sleeper enables the level line to be lowered in the tunnels in subject, i.e. on the railway line part under the road overpass by ca. 15 cm.

Steel sleepers on the HŽ railway lines (station Šapjane)
COMPACTED TUNNEL CONSOLES (CTC) WITH THE CONTACT RAIL (CR) (1)

IN THE PAST

IN THE PRESENT

Nedovoljan prostor za klasičnu konzolu

Povećanje osovinskog opterećenja i brzine zahtjeva čvršću zastornu prizmu
COMPACTED TUNNEL CONSOLES (CTC) WITH THE CONTACT RAIL (2)
COMPACTED TUNNEL CONSOLES (CTC) WITH THE CONTACT RAIL (CR) (3)

“MECHANICAL” SPACE

“ELECTRICAL” SPACE

THE CONTACT RAIL TAKES 30% LESS HEIGHT COMPARED TO THE CLASSICAL CONSTRUCTION
COMPACTED TUNNEL CONSOLES (CTC) WITH THE CONTACT RAIL (CR) (4)

- CROSS-SECTION SURFACE OF THE CONTACT RAIL IS 22 TIMES BIGGER THAN THE CLASSICAL SOLUTION

-- ELECTRICAL, EFFECTIVE CROSS SECTION IS 12 TIMES BIGGER THAN THE CLASSICAL ONE
COMPACTED TUNNEL CONSOLES (CTC) WITH THE CONTACT RAIL (CR) (5)

Permitted overtemperature
CONCLUSION (ADVANTAGES OF THE APPLIED NEW TECHNICAL SOLUTIONS)

- GREATER RELIABILITY
- GREATER AVAILABILITY
- GREATER FACILITY SAFETY
- SMALLER MAINTENANCE COSTS
- SMALLER ELECTRICITY COSTS
- SMALLER (WITHIN THE PERMITTED BOUNDARIES) ASYMMETRY OF THE ELECTRICAL POWER SYSTEM
PHASES OF SWITCHING ON OF THE 25 kV VOLTAGE (ACCORDING TO THE TECHNOLOGY DESIGN (TD))

Phase 1: Moravice (including) – Lokve (excluding)

Phase 2: (interim phase): Moravice (including) – Škrljevo (excluding)

Phase 3: Lokve (including) – Škrljevo (excluding)

Phase 4: Škrljevo (including) – Rijeka (excluding)
   Škrljevo (including) – Bakar (including)
   Sušak Pećine (including) – Rijeka
   Brajdica (including)

PLANS: WITHOUT SECTION ŠKRLJEVO - RIJEKA –ŠAPJANE THE PLANNED TIME FOR TRANSITION FROM 3 kV DC TO 25 kV AC ->12-15 DAYS
TRAIN TRACTION IN PHASE 1 (ACCORDING TO THE TECHNOLOGY DESIGN (TD))

1.) Diesel vuča
2.) Elektro vuča 3 kV

Legend for attachment 4-8
- Vuča 26 kV 50 Hz
- Diesel vuča
- Vuča 3 kV ili višesustavna lok

Diagram showing the rail traffic in phase 1 according to the technology design (TD). Cities included are: Moravice, Lokve, Škrjavo, Rijeka, Bokar, Rijeka Brajdica.

Diagram indicates:
1.) Diesel traffic
2.) Electric traffic 3 kV

City names: Moravice, Lokve, Škrjavo, Rijeka, Bokar, Rijeka Brajdica.
TRAIN TRACTION IN PHASE 3 (ACCORDING TO TD)

1.) Moravice
2.) Delnice
3.) Lokve
4.) Skrijevo
5.) Rijeka
6.) Bakar
7.) Rijeka Brijedica

Prikaz vrste vuče vlakova za vrijeme promjene sustava vuče, faza 3, dan 8 - 12

1.) Elektro vuča 25 kV 50 Hz
2.) Diesel vuča
3.) Elektro vuča 3 kV
TRAIN TRACTION IN PHASE 4 (ACCORDING TO TD)

1) Moravice

2) Lokve

3) Meja

4) Škrlevo

5) Rijeka

6) Eskar

7) Rijeka Brajdica

Prikaz vrsto vuča visokova za vrijeme promjene sustava vuče, faza 4, dani 12 - 16

1) Elektro vuča 25 kV 50 Hz
2) Na relaciji Meja - IP Škrlevo (strana A) elektro vuča 25 kV 50 Hz + Diesel vuča, IP Škrlevo (strana A) – Škrlevo DV
3) Diesel vuča
MODIFICATION FROM 3 kV DC TO 25 kV AC WAS REALIZED IN SEVEN DAYS

- Moravice (including) – Rijeka 25 kv, 50 hz
- Škrljevo (including) – Bakar 25 kv, 50 hz
- Sušak Pećine (including) – Rijeka Brajdica 25 kv, 50 hz
- Rijeka (including) – Šapjane (including) 25 kv, 50 hz
### SOME OF THE COMPANIES WHICH TOOK PART IN THE PROJECT REALISATION (1)

<table>
<thead>
<tr>
<th>Redni broj</th>
<th>Naziv firme</th>
<th>Vrsta posla koju je obavljala</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>KONČAR I DALEKOVOD</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Končar - Inženjering za energetiku i transport, Zagreb</td>
<td>Inženjering (organizacija i vođenje posla, ishođenje dozvola ), podešavanje i ispitivanje zaštite postrojenja, izvođenje radova na DU i TK</td>
</tr>
<tr>
<td>2</td>
<td>Končar - Distributivni i specijalni transformatori, Zagreb</td>
<td>Proizvodnja energetskih transformatora i prigušnica</td>
</tr>
<tr>
<td>3</td>
<td>Končar - Mjerni transformatori, Zagreb</td>
<td>Proizvodnja mjernih transformatora i provodnih izolatora</td>
</tr>
<tr>
<td>4</td>
<td>Končar - Električni visokonaponski aparat, Zagreb</td>
<td>Proizvodnja 110 kV prekidača, rastavljača i potpornih izolatora</td>
</tr>
<tr>
<td>5</td>
<td>Končar - Električni aparat srednjeg napona, Zagreb</td>
<td>Proizvodnja 25 kV prekidača, rastavljača i potpornih izolatora</td>
</tr>
<tr>
<td>6</td>
<td>Končar - Elektronika i informatika, Zagreb</td>
<td>Proizvodnja sustava istosmjernog napona 220 i 48V; izvođenje radova vezanih uz obračunsko mjerenje el. energije i mjerenje kvalitete el. energije; ugradnja u ormare i spajanje opreme za upravljanje i zaštitu postrojenja</td>
</tr>
<tr>
<td>7</td>
<td>Končar - Institut za elektrotehniku, Zagreb</td>
<td>Mjerenje otpora uzemljenja i napona dodira; ispitivanje SN kabela; ispitivanje izolacijskih ploča, motki i opreme za kratkospajanje i uzemljenje te mjerenje buke</td>
</tr>
<tr>
<td>8</td>
<td>Končar - Montažni inženjering, Zagreb</td>
<td>Izvođenje elektromontažnih radova</td>
</tr>
<tr>
<td>9</td>
<td>Dalekovod PC Inženjering</td>
<td>Inženjering (organizacija i vođenje posla, ishođenje dozvola )</td>
</tr>
<tr>
<td>10</td>
<td>Dalekovod PC Proizvodnja</td>
<td>Proizvodnja opreme</td>
</tr>
<tr>
<td>11</td>
<td>Dalekovod PC Izgradnja</td>
<td>Izgradnja KM, kabelskih tras, polaganje kabela, zgrada SPEV, izgradnja dalekovoda</td>
</tr>
<tr>
<td>12</td>
<td>Dalekovod - Laboratorij</td>
<td>Ispitivanja i mjerenja, izdavanje atesta</td>
</tr>
</tbody>
</table>
SOME OF THE COMPANIES WHICH TOOK PART IN THE PROJECT REALISATION (2)

<table>
<thead>
<tr>
<th></th>
<th>Company Details</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Ekologija i zaštita okoliša (D)</td>
<td>Izrada Elaborata o vodonepropusnosti sustava sanitarnih i oborinske odvodnje, zgrada SPEV</td>
</tr>
<tr>
<td>19</td>
<td>Geokod, Zagreb (D)</td>
<td>Izrada geodetskih elaborata, zgrada SPEV</td>
</tr>
<tr>
<td>20</td>
<td>Leopold Jordan GmbH, Podružnica Zagreb (D)</td>
<td>Izrada glavnih strojarskih projekata, zgrada SPEV</td>
</tr>
<tr>
<td>21</td>
<td>JURCON projekt, Zagreb (HŽI)</td>
<td>Stručni nadzor</td>
</tr>
<tr>
<td>22</td>
<td>JANAF, Zagreb, (HŽI)</td>
<td>Nadzor radova na rekonstrukciji katodne zaštite</td>
</tr>
<tr>
<td>23</td>
<td>PLINACRO, Zagreb, (HŽI)</td>
<td>Nadzor radova na rekonstrukciji katodne zaštite</td>
</tr>
<tr>
<td>24</td>
<td>HEP-OPS (HŽI) - temeljem sporazuma</td>
<td>Nadzor radova na 110 kV RP i 110 kV dalekovodima</td>
</tr>
<tr>
<td>25</td>
<td>HEP-ODS (HŽI) - temeljem sporazuma</td>
<td>Nadzor nad izvođenjem križanja VN i NN vodova sa prugom</td>
</tr>
<tr>
<td>26</td>
<td>HEP-OPS (HŽI)</td>
<td>Naknade za stvaranje tehničkih uvjeta u mreži za Delnice, Vrata, Plase, Sušak i Matulje</td>
</tr>
<tr>
<td>27</td>
<td>HEP-ODS (HŽI)</td>
<td>Naknade za stvaranje tehničkih uvjeta u mreži i priključenje objekata na mrežu nn</td>
</tr>
</tbody>
</table>
Finally...

- OVER 200 COMPANIES PARTICIPATED IN THE DESIGN, CONSTRUCTION AND SUPERVISION OF THE PROJECT
- METS PROJECT HAS BEEN REALIZED BASED ON OVER 2000 PRODUCED DESIGN BOOKS AND TECHNICAL SOLUTIONS
- HŽ INFRASTRUCTURE EXPERTS WERE RESPONSIBLE FOR THE PROJECT COORDINATION AND MANAGEMENT
- INVESTMENT VALUE AMOUNTS TO 637 MILLION HRK
Thank you for your attention!