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Compatibility Study of Pantographs with Head Length 1600mm and 1950mm

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Abstract: A study of European railroad systems revealed that a large number of pantographs of different lengths are used in Europe, and even in the same country, multiple types of pantographs are allowed depending on the type of line. For example, France is using the type of pantographs of 1600 mm, Norway is using the type of pantographs of 1800 mm, Austria is using the type of pantographs of 1950 mm, Estonia is using the type of pantographs of 2000 mm or 2200mm. Different lengths of pantographs have certain influence on railroad design, and various factors such as pull-out value, locator length and turnout arrangement need to be considered during contact network plan design. At the same time, different countries have their own independent requirements for pantograph types in addition to the European standards that must be met. In this paper, the use of pantograph type is analyzed through the investigation and study of a section of railroad in Serbia, and the possibility of using 1950 mm pantograph in Serbian railroad is explored. Ultimately, through practical investigation and theoretical analysis, we concluded that there was no problem in using a 1950mm pantograph in Serbia. In addition to the influence factors mentioned in the paper, the actual design also needs to consider the problem of connecting with the existing line.

Keywords: Pantographs, Lengths, Contact Network, European Standards

1. Introduction

In the railway network in Europe, a large number of pantographs of different lengths of pantograph heads are in use, and in the same country, depending on the type of line (conventional or high-speed network), or on the same line, several types of pantographs can be used [1-9]:

1600mm - France, Great Britain, Portugal, Switzerland, Norway, Italy, the Netherlands, Germany, Austria, Croatia, Serbia;

1800mm - Norway, Sweden;

1950mm - Belgium, Denmark, Germany, Austria, France, Hungary;

2000/2260mm - Finland, Estonia, Latvia, Lithuania.

The regulations on technical requirements for the subsystem energy, prescribes the mandatory use of pantograph head length of 1600mm on the railway network in Serbia, which should meet the requirements of standard EN 50367: 2013. All vehicles operating on electrified railways of Serbia are equipped with this type of pantograph.

Considering that the Belgrade Center - StaraPazova railway consists of two subsections in terms of the characteristics of the applied overhead contact system, analysis of the possibility of using a 1950mm pantograph was done separately for the section from Belgrade Center to Batajnica (inclusive), and from Batajnica to StaraPazova.

This paper verifies the pantograph models suitable for Serbia by investigating and researching pantographs of different lengths.

2. Analysis of the Space Required for the Passage of the 1950mm Pantograph

2.1. Section Belgrade Center-Batajnica (Inclusive)

According to the overhead contact system standard solutions used on railways in Serbia, the length of the steady arm to be applied is selected according to the following table:

Table 1. *Selection of steady arm length depending on the conditions of its use.*

	Stagger (mm) 300-150	Stagger (mm) 149-0	Stagger above switches
Steady arm length (mm)	900	1100	1350

Using the steady arm according to the above table, the hook for attaching the steady arm is located outside the kinematic-mechanical gauge of the pantograph. [10]

The possibility of using the 1950mm pantograph will be checked according to the same criteria, taking for comparison the calculated mechanical-kinematic gauge of the 1950mm pantograph, for characteristic cases:

1. Open track:
   a) straight line

For this case, the relation between a standard cantilever with a shortest steady arm of 900mm and a pantograph 1950mm is shown.

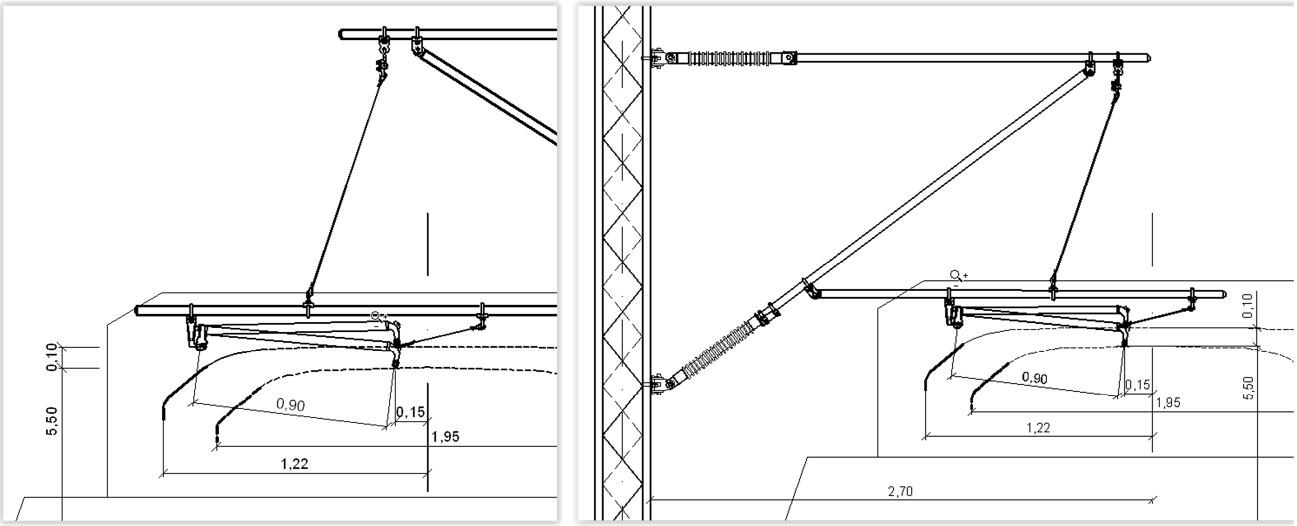

Figure 1. *Open track in straight line with pantograph 1950mm.*

b) curve with 300m radius with outer rail cant of 150mm (pull-off and push-off cantilever)

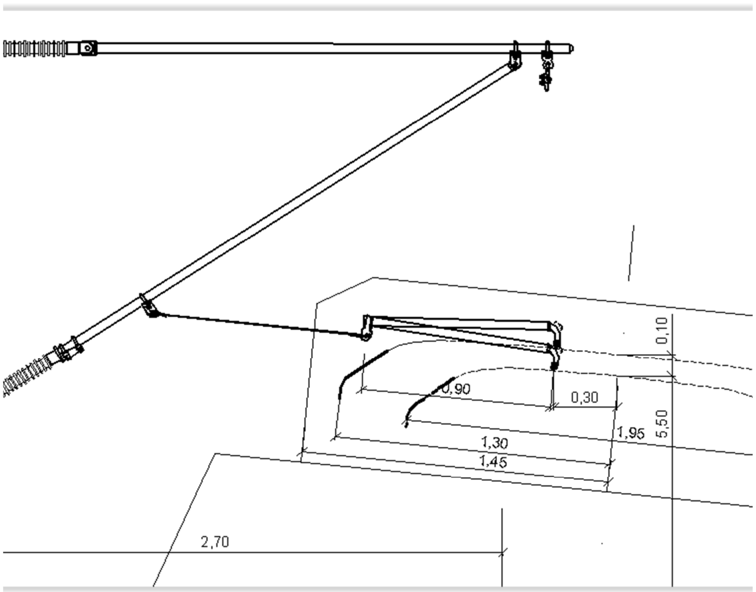

Figure 2. *Open track in curve (with 150mm cant) with pantograph 1950mm (pull-off and push-off cantilever).*

According to Figures 1 and 2, it can be seen that the clamp of the steady arm support is in the immediate vicinity of the kinematic-mechanical gauge for the case of using a 1950mm pantograph, ie that the tolerances are significantly reduced compared to the 1600mm pantograph.

Therefore, for this case, it would be recommended to replace the 900mm steady arm with the 1100mm steady arm (for the push-off cantilever, it is necessary to also replace the steady arm support), which would achieve the same degree of reserve for the 1950mm pantograph as for the 1600mm pantograph. [11]

Alternatively, a variant with increasing the slope of the steady arm and raising the steady arm bracket by about 5-10 cm should be considered, in order to achieve a greater distance from theclamp of the steady arm hook (similar to the active cantilever in an insulated overlap, where the distance between the steady arm support and the contact wire is 32 cm instead of the standard 25cm).

2. Overhead contact lines passing over switches

Considering that the scope of consideration is the section from Belgrade Center to Batajnica, the switches of type R300-6° were considered, which primarily exist on that section. [12-14]

The passage of overhead contact lines in the turnout is done by means of intersections or tangentially, and in both cases the wires support is done in the zone of the mathematical center of the turnout, where the distance between the tracks is about 0.41 m. Attention is paid to the fact that both contact lines are on the same side of the pantograph, both for the straight track and for the branch track. As a rule, the contact line for the branch line rises by 2-5 cm, depending on whether it is a crossing or tangential passing.

The usual staggers in relation to the straight track are + 100mm (for the branch contact line) and + 200mm (for the straight contact line), and steady arms with a length of 1350 mm are used as standard, with the use of steady arm support clamps outside the 1600mm pantograph profile.

The following figure shows the described design with a 1950mm pantograph gauge.

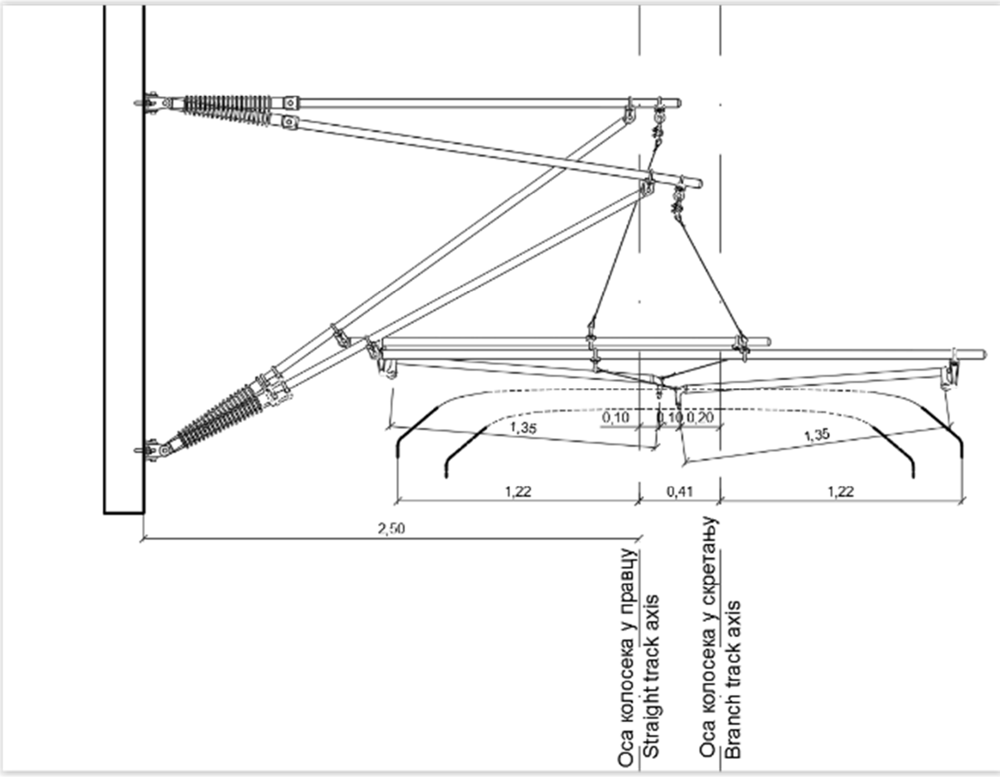

Figure 3. *Overhead contact lines passing over switches with pantograph 1950mm.*

It can be concluded that on at least one cantilever (right in the case shown), the steady arm bracket clamp is above the pantograph gauge, instead of outside it, as is usual in standard practice.

The existing technical solutions applied on electrified railway lines in Serbia do not envisage the use of steady arms longer than 1350 mm, and depending on the distance of the supporting structure from the track axis, it is possible that in many cases there is not enough space for its application.

Therefore, itmay be necessary to consider the variant with raising the steady arm support by 5-10 cm, in order to additionally raise the steady arm support clamp above the gauge of the pantograph, or the use of a curved steady arm.

Tunnel

Support of the overhead contact system in the Bežanijska kosa tunnel is planned with standard tunnel cantilevers (standard designs TR2-551 and TR2-552 of the OCS catalog), which are in use on the Serbian railways. [15]

Due to the limited space in the tunnel, the position of the cantilevers is determined so that the calculated minimum infrastructure gauge of the pantograph 1600mm is obtained (considering the characteristics of the applied cantilevers, the electric clearance must be taken into account also, except at the isolated horns).

The following figures show the cross section in the tunnel "Bežanijska kosa" with infrastructure gauges for the pantographs 1600mm and 1950mm.

In the case of using a 1950mm pantograph (Figure 7), the mechanical-kinetic gauge of the pantograph is compromised by the brackets, while the infrastrucure gauge of the pantograph, which in this case includes the necessary electrical clearances outside uninsulated horns, extends almost to the tunnel wall.

Therefore, it can be concluded that the application of a 1950mm pantograph with the used technical designs is not possible. Application of other means of OCS support would require additional analyses. [16]

2.2. Section Batajnica-Starapazova

Similar to section Belgrade – Batajnica, the possibility of using the 1950mm pantograph will be checked according to the same criteria, taking for comparison the calculated mechanical-kinematic gauge of the 1950mm pantograph, for characteristic cases:

The selection principle of steady arm in sectionBatajnica to Stara Pazova is shown in the table below:

Table 2. *Selection of steady arm for main line depending on the conditions of its use.*

Stagger (mm)	**300**	**200-299**	**100-199**	**0-99**
The length of steady arm (mm)	1000	1100	1200	1300

Table 3. *Selection of steady arm for side line depending on the conditions of its use.*

Stagger (mm)	**200-299**	**100-199**	**0-99**
The length of steady arm (mm)	900	1000	1100

Table 4. *Selection of steady arm for turnout line depending on the conditions of its use.*

Stagger (mm)	**200-299**	**100-199**	**0-99**
The length of steady arm (mm)	900	1000	1100

According to the selection principle of steady arm and cantilever pre-configuration results, the length of OCS steady arms in section Batajnica to Stara Pazovais mainly divided into 1100mm and 1200mm, and 1000mm is used for individual steady arms in Stara Pazova station. According to the content analysis in Section 2, the steady arms and steady arm base with a length of more than 1100mm will be located outside the dynamic envelope of 1950mm pantograph, which is applicable to 1950mm pantograph.

The installation diagram of 1000mm steady arms at the straight line and the curve of 150mm outer rail superelevation is shown in the figure below.

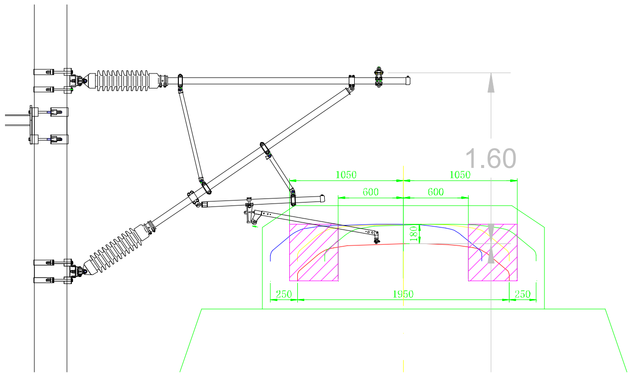

Figure 4. *Typical installation diagram of catenary in straight section.*

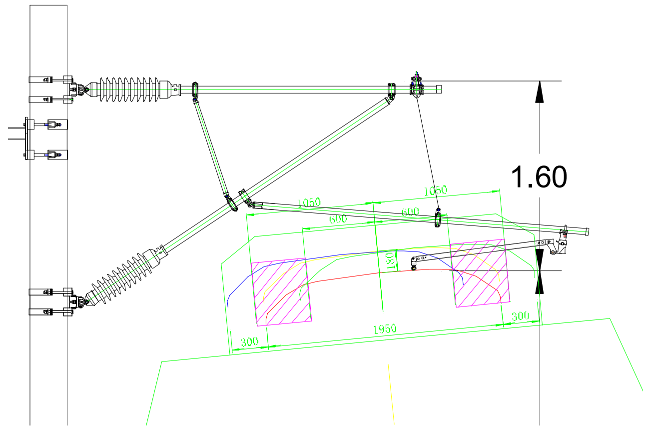

Figure 5. *Typical installation diagram of overhead contact system under superelevation of 150mm outer rail -- positioning in curve.*

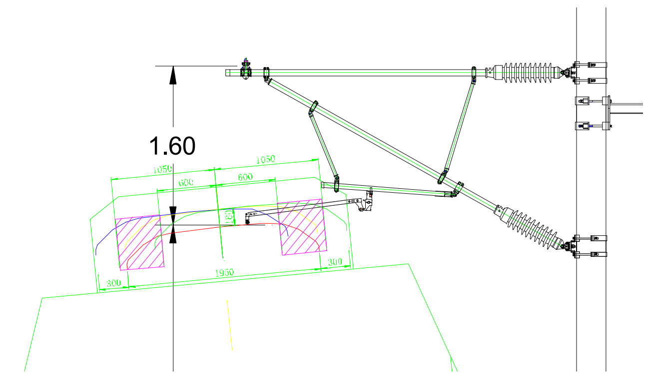

Figure 6. *Typical installation diagram of overhead contact system under 150 mm outer rail superelevation -- curved outer reverse positioning.*

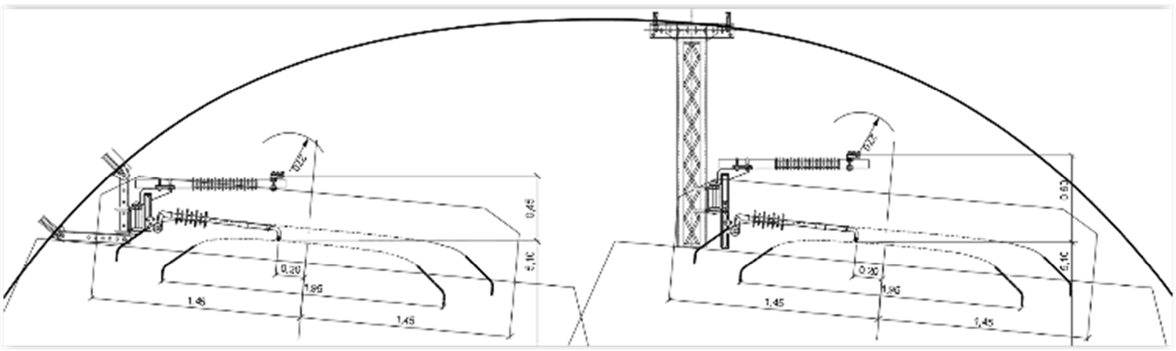

Figure 7. *Designed overhead contact system in the tunnel 'Bežanijska kosa' with pantograph 1950mm gauges.*

It can be seen from the figure that for linear section, 1000mm steady arms are not within the dynamic envelope of 1950mm pantograph. For the curve of 150mm outer rail superelevation, the steady arm base with a length of 1000mm steady arm in the curve intrudes into the dynamic envelope of the pantograph. Therefore, in order to meet the operation and installation of locomotive and ensure the reliability of catenary system, it is recommended to adjust the angle of steady arm pipe and the gradient of steady arm on site to meet the operation requirements of 1950mm pantograph, and there is the possibility of replacing locator in some cases.

Study on applicability of OCS installation mode at turnout

The catenary of section Batajnica - Stara Pazovaadopts cross positioning mode, and the positioning principles are as follows:

The position of turnout positioning column shall be comprehensively determined according to turnout type, pull-out value and other factors.

Within the initial contact area of turnout, two contact wires must be located on the same side of pantograph. No clamp other than dropper clamp shall be installed in the initial contact area of turnout.

When one of the two contact lines in the initial contact area of the turnout is the main line and the other is the station line, the station line contact line shall be 10 ~ 20mm higher than the main line contact line. When both are station lines, the two contact lines shall be equal in height.

For the main line turnout, the contact line of side line is at the positioning point, which shall be increased as much as possible under the condition of ensuring that there is no uplift force at the intersection.

The non-clamp area of 1950mm pantograph is 600-1050mm, which is greatly different from that of 1600mm pantograph (450-875mm). At present, it needs to be adjusted to be compatible with pantographs of two widths at the same time, so the non-clamp area expands to 450-1050mm. According to the positioning principle of overhead contact system turnout, the position and pull-out value of positioning column of 1950mm and 1600mm pantograph at different turnouts in section Batajnica to Stara Pazova are determined as shown in the following table:

Table 5. *Installation principle of turnout applicable to two types of pantograph*

Track type(kg/m)	Turnout angle	Turnout type	Distance between turnout intersection and the positioning mast in front of it (m)	Distance between turnout intersection and the positioning mast behind it (m)
60	6°	60E1-300-6°	0 (stagger value of 350 for main line; stagger value of 350 for side track)	35 (stagger value of 0 for main line; stagger value of 200 for side track)
	14	60E1-760-1/14	16.532 (stagger value of 200 for main line; stagger value of 350 for side track)	16.468 (stagger value of 0 for main line; stagger value of 150 for side track)
	18.5	60E1-1200-1/18.5	17.646 (stagger value of 200 for main line; stagger value of 350 for side track)	22.354 (stagger value of 0 for main line; stagger value of 150 for side track)
49	6°	49E1-300-6°	0 (stagger value of 350 for main line; stagger value of 350 for side track)	35 (stagger value of 0 for main line; stagger value of 150 for side track)
	6°	49E1-200-6°	0 (stagger value of 350 for main line; stagger value of 350 for side track)	35 (stagger value of 0 for main line; stagger value of 150 for side track)

2.3. Insulation Distance Verification

The insulation distance between 25kV and fixed grounding body shall meet the following requirements:

The static insulation distance shall not be less than 270mm and the dynamic insulation distance shall not be less than 150mm.

The multi track parallel section in section Batajnica to Stara Pazova is installed in the form of portal structure. Through the verification of the lower davit gauge, cantilever and positioning installation of the portal structure of the OCS in the construction drawing design, the verification results show that the lower davit, cantilever and steady arm of the portal structure in the multi track parallel sections of Nova Pazova station and Stara Pazova station. The positioning support shall meet the requirements of dynamic envelope of 1950mm pantograph and insulation distance of 25kV electrified.

3. Conclusion

3.1. Section Belgrade Center-Batajnica

The existing overhead contact system used in Serbia, designed for driving speeds up to 120 (160) km/h, which is designed on the section Belgrade Center-Batajnica, is not intended for the use of pantographs with a head length of 1950 mm. The application of the mentioned pantograph would require adjustment of the elements of the OCS in the manner shown in the previous section, where there may be additional possible collisions that are not treated here, and which depend on the specific location (section and cut-in insulators placed close to the tracks, portal droppers placed at minimum distances between the tracks, and the like).

At certain locations, it is probable that the supporting OCS structures would have to be relocated in order to provide space for the passage of the pantograph, but a specific analysis would have to be performed for each individual track where 1950mm pantograph should be used.

3.2. Section Batajnica-Stara Pazova

The main problem of section Batajnica-Stara Pazova lies in the positioning mode of OCS at the turnout. For 200-6° and 300-6° turnouts, it is necessary to move the pole position near the turnout. Even in special cases, additional columns are required. The OCS at other types of turnout only need to be slightly adjusted. Similar to the section Belgrade center-Batajnica mentioned above, some other parts may have conflicts with 1950mm pantograph, which need to be measured and studied according to the actual location.

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