Study on the Location of Six-Span Phase Separation of 27.5kv Flexible Catenary in Subway

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Keywords: Rail transit, Catenary, Six-span electrical phase separation

Abstract: This research is based on the flexible OCS system of Chengdu Metro Line 17, and analyzes and demonstrates the rationality of the six-span OCS electrical phase separation location from the perspective of the preconditions of electrical phase separation in tunnels and the constraints of subway lines.

1. Introduction

Chengdu Metro Line 17 adopts 27.5kV AC flexible catenary as the background power supply system, which is the first case in the national subway. There are some restrictive factors in the construction and installation of flexible catenary in subway environment, especially the electrical phase separation position is more serious. In the subway environment, the interval length is short and the train speed is restricted by different conditions; At the same time, the train must meet the corresponding minimum speed requirement when passing through the electric phase separation position. By analyzing and calculating the relationship between them, this paper makes an in-depth discussion on the location of the six-span split-phase subway.

2. Train Operation Environment of Chengdu No.17 Line

2.1 Overview of the Project:

The main line of the first phase of Chengdu Metro Line 17 is about 26.145km long, of which the elevated section is about 4.86km long, the subgrade transition section is about 0.5km long and the underground section is 20.785km; long,There are 9 stations, including 2 elevated stations and 7 underground stations. The maximum station spacing is about 6.7km, the minimum station spacing is about 1.5km, and the average station spacing is about 3.18km .. Eight metro A-type cars with a target speed of 140km/h are grouped, and 25kV overhead catenary is used for power supply.

2.2 The Distance between Stations of Chengdu Line 17 is as Follows:

Table 1 Statistical Table Of Distance Length between Stations

serial number	origin station	terminal	Station spacing (km)	Electric phase separation setting
one	Jinxing station	Huangshi Station	4.278	
2	Huangshi Station	Shiwu hospital station	2.967	
three	Shiwu hospital station	Fengxihe Station	1.848	
four	Fengxihe Station	Wenquan boulevard station	2.04	
five	Wenquan boulevard station	mingguang railway station	1.973	Set electrical phase separation
six	mingguang railway station	jiujiang north railway station	6.618	
seven	jiujiang north railway station	Baifoqiao Station	4.177	Set electrical phase separation
eight	Baifoqiao Station	Jitouqiao Station Bridge Station	1.468	

2.3 Orbital Environment:

  DOI: 10.25236/mmmce.2021.009

The main line of Chengdu Line 17 is designed to have a maximum driving speed of 140km/h, and the track engineering design meets the operation requirement of instantaneous maximum speed of 160km/h; The minimum curve radius is 450m, the maximum slope is 29‰, and the minimum slope is 3.007‰. The requirements of track specialty on train speed are mainly at turnout position and curve position, and the speed limit requirements of track specialty of Chengdu Line 17 are as follows:

Table 2 Speed Limit Of Turnout Structure

serial number	Turnout type	Direct speed limit of track structure (km)	Lateral speed limit of track structure (km)	This case relates to turnouts
one	Single turnout with 60kgm rail curved point rail No.12 concrete long turnout sleeper	160	50	jiujiang north railway station
2	Single turnout with 60kgm rail curve sharp rail No.9 concrete long turnout sleeper	120	35	Mingguang Station, jiujiang north railway station
three	60kgm rail curve point rail No.12 concrete long turnout sleeper crossing turnout	160	50	
four	60kgm rail No.9 5.0m distance crossing turnout	120	35	
five	60kgm rail No.9 crossing switch with 5.5m spacing	120	35	
six	60kgm rail No.9 17.2m distance crossing turnout	120	35	

2.4 Train Environment:

The trains on Chengdu Line 17 are composed of 8 metro A-cars with a total length of 187.332m. The acceleration and braking distances of trains with different passengers are as follows:

Table 3 Train Acceleration Distance

serial number	Speed (kmh)	AW0 running distance (m)	AW2 running distance (m)	AW3 running distance (m)
one	0	0.00	0.00	0.00
2	10	3.62	3.64	4.04
three	20	14.49	14.55	16.17
four	30	32.62	32.75	36.40
five	40	58.03	58.26	64.75
six	50	91.90	93.37	103.78
seven	60	132.90	145.52	157.67
eight	70	188.82	218.56	239.22
nine	80	263.43	316.27	345.67
10	90	360.24	442.63	487.70
11	100	481.93	601.84	667.35
12	110	643.24	810.29	903.33
13	120	859.95	1089.77	1216.53
14	130	1322.85	1704.12	1889.47
15	140	1522.22	1970.46	2183.45

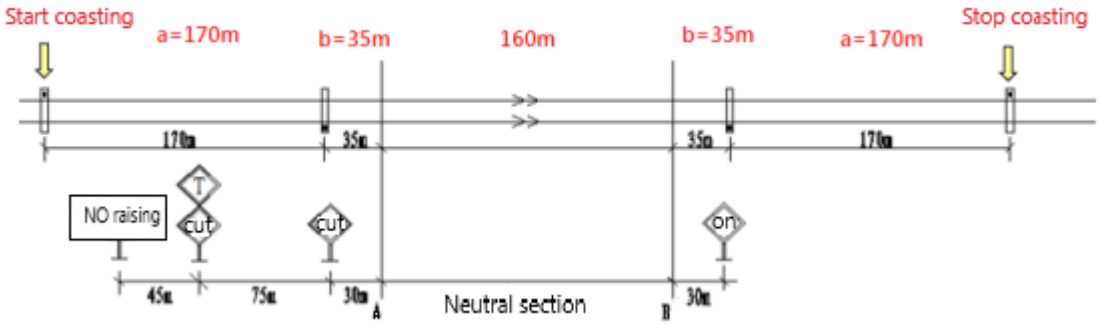
Table 4 Train Braking Distance

serial number	Speed (kmh)	AW0 braking distance (m)		AW2 braking distance (m)		AW3 braking distance (m)	
		Maximum service brake	emergency braking	Maximum service brake	emergency braking	Maximum service brake	emergency braking
one	140	756	631	756	631	756	631
2	135	706	587	706	587	706	587
three	130	656	546	656	546	656	546
four	125	609	506	609	506	609	506
five	120	562	468	562	468	562	468
six	110	476	396	476	396	476	396

seven	100	397	330	397	330	397	330
eight	90	325	270	325	270	325	270
nine	80	260	216	260	216	260	216
10	70	202	168	202	168	202	168
11	60	152	126	152	126	152	126
12	50	109	90	109	90	109	90
13	40	seventy-two	60	seventy-two	60	seventy-two	60
14	30	forty-four	36	forty-four	36	forty-four	36
15	20	22	18	22	18	22	18
16	10	eight	six	eight	six	eight	six

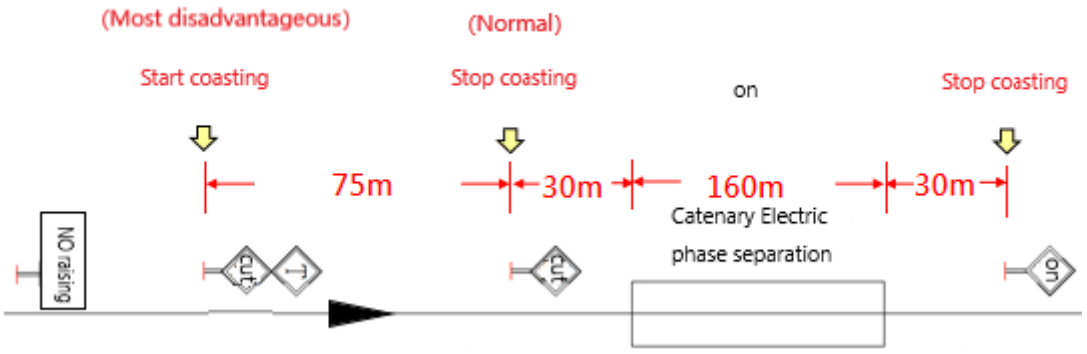
2.5 Electric Phase Separation Setting Environment:

The OCS phase separation is composed of two four-span insulation joints, and when considering their distance, it should be the sum of six-span span length and inertia travel distance. Under normal operation mode, the train automatically crosses the phase, and the total length of the train idle section is about 170+35+160+35+170=570m, as shown in the following figure:



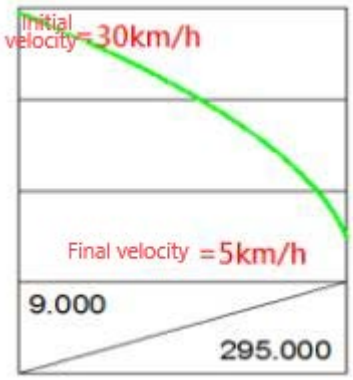
Fig,1 Idle Range of Normally Operating Trains -1

According to the requirements of Railway Technical Management Regulations (Tiezong Science & Technology [2014] No.172), a power-off sign and a double bow sign are respectively set in front of the OCS electrical phase in the electrified section. For passenger trains with the maximum running speed greater than 120km/h, a special power failure sign (T-break) is added in front of the power failure sign. Under the abnormal operation mode (including the push mode of the faulty vehicle), the driver needs to manually cross the phase, and the total length of the idle section of the train is about 75+30+160+30=295m.



Fig,2 Idle Range of Abnormally Operated Trains -2

According to the requirements of “Matching Criteria for Power-off and Phase-crossing Systems of Rail Transit Passenger Trains”, the exit speed before the “closing” bid should not be lower than 5km/h under the speed limit mode of fault operation. According to the idle distance of the train in abnormal operation =295m, and considering the limit conditions of rail line, the maximum slope =9‰ and the final speed =5km/h, the initial speed is calculated as 30km/H.



Fig,3 Schematic Diagram of Speed in Extreme Case -3

2.6 Design Drawings:

According to the main line layout and main line signal layout of Chengdu Line 17 catenary, the design position of electrical phase separation is as follows:

Table 4 Design Position Of Electrical Phase Separation

serial number	Phase center mileage	Crossing mode	Parking mileage	Distance from inert point of electrical phase separation to parking point (m)
one	ZDK64+050	outbound	ZDK64+627	64627-64050-5702=292
2	YDK64+050	get in	YDK64+814	64814-64050+5702=1049
three	ZDK72+130	get in	ZDK71+268	72130-71268+5702=1147
four	YDK72+130	outbound	YDK71+455	72130-71455-+5702=390

2.7 This Paper Analyzes and Demonstrates the Feasibility of Setting Up Electrical Phase Separation for Chengdu Line 17

There are four electrical phases involved in this case, which are named as left line 1(ZDK64+050), left line 2(ZDK72+130), right line 1(YDK64+050) and right line 2(YDK71+455). Here, by calculating the distance from the inertia point to the stop of the train on the inbound side; By comparing the data obtained above, the rationality of the six-span split phase of OCS on this line is demonstrated.

Trains passing through turnouts in different phases all pass in a straight direction, and the speed limit is not more than 120km/h; It can be seen from the design drawings of track specialty that all the incoming ends to the stations of the two electric phases in this case are straight lines, and all the sections from the outgoing ends to the maximum speed are straight lines. Therefore, the speed of trains at the two electric phase separation positions is not affected by the factors of track curve radius, curve superelevation and slope rate, and can run normally at the designed speed.

According to “Table 3 Train Acceleration Distance”, it can be found that the length required to speed up to 30km/h is 36.4m under extreme overload (AW3).

According to “table 4 train braking distance”, it can be found that under the condition of extreme overload (AW3), the required length for braking from 140km/h to 0km/h is 756m.

3. Conclusion

The left line 1 and the right line 2 are outbound positions, and the distance required for the train to speed up to 30km/h from the parking point to the inertia point is greater than 36.4 m; The left line 2 and the right line 12 are the entrance positions, and the distance between braking from the inertia point and stopping is more than 756m. Therefore, it can be concluded that the setting position of six-span electrical phase separation of OCS on Chengdu Line 17 is reasonable.

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