Field Measurement of Passing Pressure on High Speed Maglev Vehicles

(*)WANG Fengming,HU Jie,SUN Yongfang,(**)LI Mingshui
(*)National Maglev Transportation Engineering R&D Center, Shanghai 201204
Telephone: +86-21-28907309, E-mail: wfm55@yahoo.com
(**)China Aerodynamics R&D Center, Mianyang, Sichuan 621000

Key Word:

Maglev vehicles, pressure load caused by passing Maglev vehicles, trial operation field measurement

Abstract:

The pressure load caused by passing Maglev vehicles has an important aerodynamic effect on safety and comfort. In order to verify the design of the vehicle, a testing of the aerodynamic pressure loads on Maglev vehicles was carried out in Shanghai in Nov. 2003. The field measurements were performed at the conditions of 5.1m track distance while the passing speeds of Maglev vehicles vary from 400km/h to 500km/h.

1 Introduction

When two vehicles passing each other at a high relative speed, the consequential crush effect on the air between these two vehicles will bring air turbulence and air pressure load. Working on the head and side of the vehicles, the pressure load will not only affect the stability and ride comfort, but also cause damages to the windows located in the head and side of the vehicles. The magnitude of pressure load is proportional to the square of running speed and has close relationship with such elements as the shape of vehicle, the distance between the centers of two tracks. Regarding the Shanghai demonstration line, the shape of vehicle and the distance between the centers of two vehicles have been defined beforehand. As a result the running speed is the decisive factor to the magnitude of pressure load. In order to analyze the pressure load caused by the passing of the two vehicles and verify the safety of the vehicle, a field measurement testing was conducted with maximum speed of 501 km/h on November 2003 in Shanghai.

Two maglev trains were used in the testing. One is a five-section-vehicle, called PV2, the other is a three-section-vehicle, called PV3. For the investigation of the outer pressure load, pressure sensors have been installed on defined measuring points on PV3. The pressure load worked on PV3 is to be measured at varying relative speeds.

2 Testing Procedure

2.1 Pressure Loads Caused by Passing Vehicle

On the basis of previous investigation carried out on Shanghai Line by IABG , 5 measurement points, namely P_Door, P_Window, P_Longi_2, P_WKUB_2 and P_Longi_3 were chosen to conduct the test , see figures 1.

The whole testing system consists of several pressure sensors, an amplifier, an A/D converter and a computer for further processing and recording of test data. All devices except pressure sensors were mounted and operated inside vehicles.

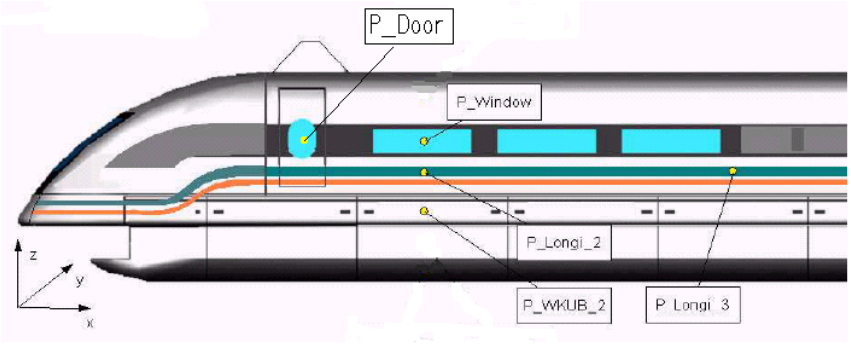

Fig.1 Locations of the measuring points

3 Data Acquisition and processing

3.1 Pressure Load Caused by Passing Vehicles

Although the sampling rate was set to 5kHz and a raw data filter (Butterworth characteristic) to 1kHz, it is necessary to filter the pressure signal by using a low pass digital filter. The frequency of the digital filter was calculated on the basis of half of relative running speed of two Maglev vehicles, based on the experience of IABG Co. It can be seen that the pressure loads on PV2 increase quickly from a low value (P_0), which depends on running velocity of vehicles and natural wind environment, to a peak when PV3 is approaching and meeting. Then a fast pressure decrease to a negative peak follows while the bow passes. The pressure level at the cylindrical part of the vehicle returns almost to about a constant and at the end of PV3 a negative peak is followed by a positive as an effect of tail passing. The pressure fluctuation after vehicle passing can be explained by the presence of turbulences within the vortex trailing.

It is reasonable to take P_0 as the 0, i.e. the coordinate axis of pressure moves from P_0 to 0, so that only the pure pressure loads caused by passing can be found, see fig.3. It is noted that P_pass is fluctuating pressure induced by passing vehicle.

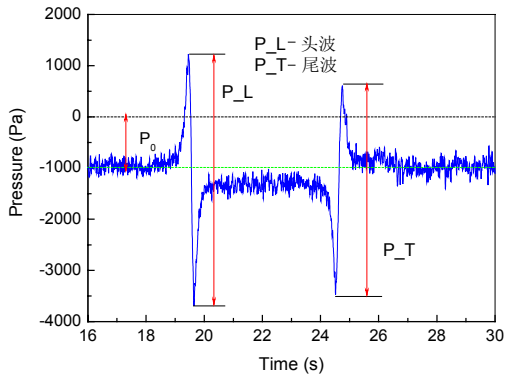

Fig.2 The raw pressure signal

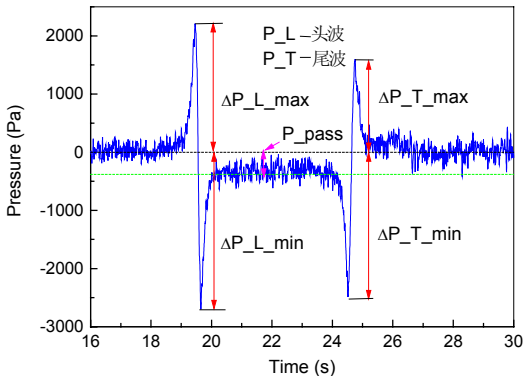

Fig.3 The pressure signal after reduction

4 Results of the Test

4.1 pressure load caused by passing vehicles

4.1.1 Standing Passing

The ´standing´ passing means PV3 parks at somewhere on the track while PV2 is running at a certain speed. Fig 4 shows the mounting location of sensors. Leading to leading (LL) passing or Leading to trailing (LT) passing means that PV2 is running from LYR to PIA, while leading to trailing (TL) passing or trailing to trailing (TT) passing indicates that PV2 is running from PIA to LYR.

Table 1 gives the average amplitudes values on all testing points derived from measurements results when PV2 was moving from LYR to PIA at the speed of 500km/h.

4.1.2 Flying Passing

The ´flying´ passing means PV3 is running at a certain speed while PV2 is also moving but in inverse direction. Leading to leading (LL) passing or Leading to trailing passing (LT) means that PV2 was running from LYR to PIA and PV3 was running from PIA to LYR, see fig 5. Leading to trailing (TL) passing and trailing to trailing (TT) passing indicates that PV2 was running from PIA to LYR and PV3 from LYR to PIA.

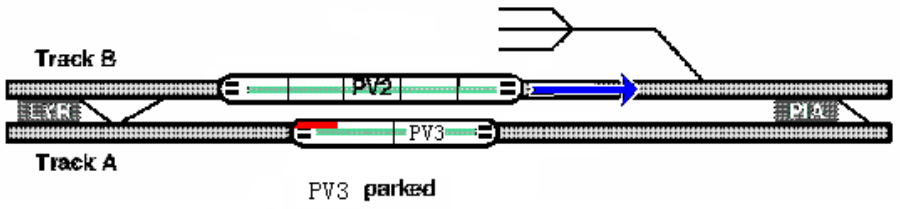

Fig.4 The standing passing

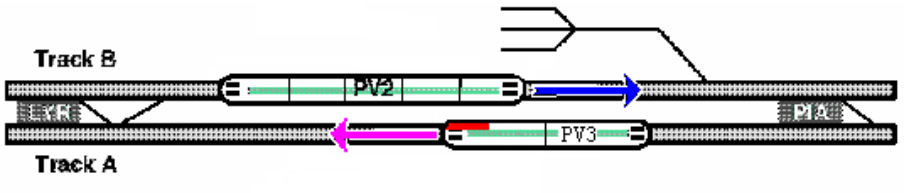

Fig.5 The flying passing: leading to leading

Table 1 The average pressure of standing passing (Unit: pa)

Testing Point	ΔP_L_ max	ΔP_L_ min	ΔP_T_ max	ΔP_T_ min
P_Door	2181	-2766	1490	-1997
P_Window	1842	-2484	1326	-1803
P_Longi_2	2037	-2423	1366	-1626
P_WKUB_2	2109	-2785	1502	-1727
P_Longi_3	1977	-2606	1345	-1586

Table 2 The average pressure of flying passing (Unit: pa)

Testing Poin	ΔP_L_ max	ΔP_L_ min	ΔP_T_ max	ΔP_T_ min
P_Door	2130	-2627	1537	-2418
P_Window	1561	-2129	1234	-1479
P_Longi_2	1778	-2083	1343	-1417
P_WKUB_2	1657	-2118	1344	-1099
P_Longi_3	1779	-2163	1372	-1569

The average values derived from measurements results are given in Table 2 .During the test, PV2 was running from LYR to PIA at the speed of 500km/h and PV3 was running from PIA to LYR at the speed of 400 km/h .

5 Conclusion

It is noted that the absolute value of the maximum amplitude(plus and minus) of passing pressure load at every measurement point except point 'P_Door' is less than 2250Pa, which is the assumed maximum pressure load by designers. The passing pressure load at measurement point 'P_Door' is found to be larger than that assumed . More attention should be paid to the distribution of pressure load, in particular in the area of entrance door, in the further development of the vehicle car body.