

# *Taoyuan Airport MRT EMU Vibration Prevention And Improvement Program Research*

*Fuh Shyong Yang*

National Taipei University of Technology,  
Taiwan

*Go Long Tsai*

National Taipei University of Technology,  
Taiwan

*Yu Ting Tseng*

National Taipei University of Technology,  
Taiwan

**Abstract**—This study is based on the straight-line acceleration section and the occurrence of the jitter position on the operational routes, five sections are selected for the general survey, and then one section is selected for monitoring and analysis purposes. In addition, we try to find whether the corrugation phenomenon of the curved rail section affects the train or not?

In this way, the steel wheel turning can be redefined, and the process should focus on the arc relationship; the Taoyuan MRT route, combined with multiple curved and long steep slopes routes, those will cause the rails corrugation, and the frequency of the steel wheel out of round is much higher than other MRT systems.

**Keywords**—Wheel, Vibration, Bogie, Railway Vehicle, Corrugation, Steel Wheel Turning

## I. Introduction

Since the opening of the Taoyuan MRT (formally operating on March 2, 106), it has been shouldering the heavy responsibility of leading the country to Taipei, and has become one of the Taoyuan area, New Taipei City, Taipei City, going abroad and commuting transportation. According to the latest statistics (June 108), there are a maximum of 83,369 person-times per day, a total of 2,277,863 person-times during the month, and an average of 75,929 person-times. [1]

In some route sections and under certain conditions (such as rainy days and high-speed driving), abnormal train vibrations occur. We are most worried about whether the train will cause derailment or derailment due to excessive vibration, which will affect passenger safety. In addition, what puzzles us is that before being handed over to the user (Taoyuan MRT Corporation), we often used the electric car to perform related tests: such as the operation of the sign ATO, ATP, and functional verification with water ring standards. , Stopping distance on long and steep slopes, on-time operation of train schedules, train weight (W3) verification, reliability verification, maintainability verification, and pressure test, etc. are all completed in the main line segment regardless of the area. During the verification period, no jitter occurred at the high speed of the train.

Also because of the route, the train will have a single side steel wheel wear, hard points on the steel wheel surface due to braking, wear on the inside of the transition rail area and turning rims, for various reasons, the steel wheel turning of the train is higher than other MRT systems There are many, so we also list this as one of the factors. Until the train was delivered to the MRT company, we did not turn the steel wheels of the intermodal train. Therefore, we suspect that the high-speed abnormal vibration of the train caused by turning the steel wheels.

Wang Weihui et al. (89) mentioned that the human body is most sensitive to vibration between 1 and 80 Hz. Generally speaking, there are round steel wheels, uneven track treads, base plate distance, natural vibration frequency of the track bed, natural vibration frequency of the wheel set, and so on. Vibration has a great impact on the human body, and the effects on the human body can be divided into four categories: non-sensing, conscious, annoying, and painful [2].

## II. Methods

In this study, Kawasaki Heavy Industries was responsible for setting up the type testing equipment [3], and carrying out the test of the experimental group and the control group of the train with the empty load (W0) to verify whether the current train meets the requirements of the original type testing [3]. Sections A12-A11 were selected in order to compare the measurement results at this time with the results of the type test performed here. As a result, the trains of the experimental group and the control group were in compliance.

After verifying that the train is completely in good condition, the vibration measurement instrument installation begins next. Prepare X, Y, and Z axis accelerometers, GPS speed meters, and GOPRO cameras. Set up two X, Y, and Z axis vibration acceleration average measuring instruments in the car, the installation positions are located in the middle of the floor in front of each train (DME1 + DMB), above the No. 1 bogie, it can record the train's travel X, Y, Z phase shift. In addition, GOPRO is set under the position of the No. 1 bogie to record the operation of the bogie, and GPS is used to measure the vehicle speed. (Figure 1)

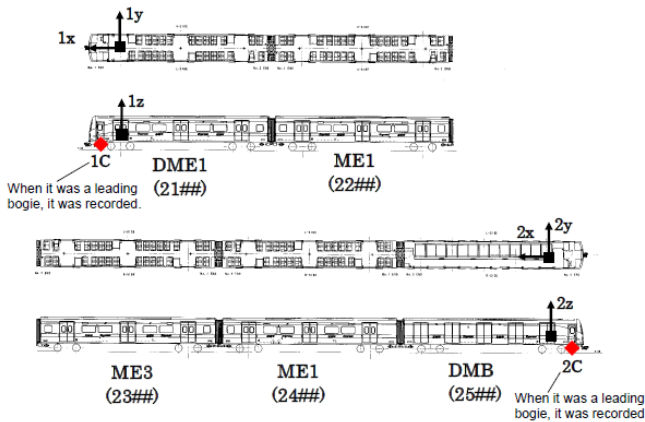


Figure 1: Schematic diagram of measuring equipment placement

It is estimated that the test will last for 13 days (one day is left as the preparation day). One train will be used every day. The equipment will be erected on the train to be tested during the day. After using the last train at night, the test train followed the last train for testing. We used three direct trains and three ordinary trains as the control group, and the other three direct trains and three ordinary trains as the experimental group.

First, check the bogie steel wheels, and then measure the steel wheel diameter of the train with the wheel diameter gauge [4]. (Figure 2)

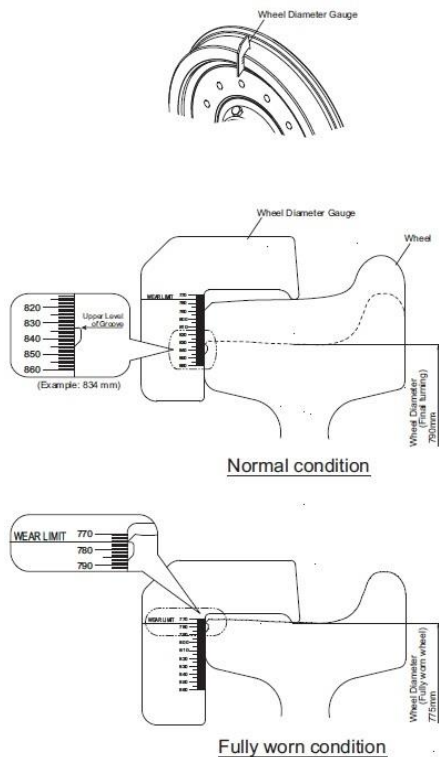


Figure 2: Wheel diameter measurement [4]

The standard is wheel diameter greater than 775 mm (new: 850 mm). Wear below 775 mm or lower must be replaced for wear. The diameter difference exceeds the criterion of the "Acceptable Rate Criterion", and the relevant frame should be rounded to make the diameter difference within the criterion range [4]. (As shown in Table 1)

Table 1: Acceptable difference criteria [4]

Position	Variation
Within the same axle	1mm or less
Within the same Bogie	3mm or less
Within the same car	6mm or less

Next, check the cross-section dimensions of the wheels and record the tread curvature [4]. The standard is shown in Table 2. Sequentially the wheel contour wear limit [4] is shown in Figure 3. The rim slope [4] is shown in Figure 4. The rim thickness and height [4] is shown in Figure 5.

Table 2: New and fully worn wheel diameters [4]

	New (Ref) (mm)	Fully Worn (mm)
Flange Height	28	36
Flange Thickness	32.5	27.5
Flange Slope	10.8	6.5

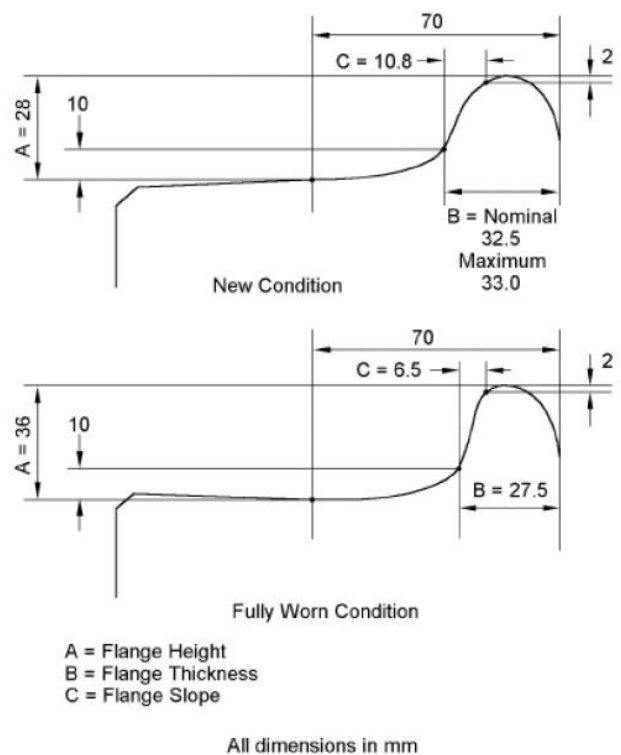


Figure 3: Wheel contour wear limit [4]

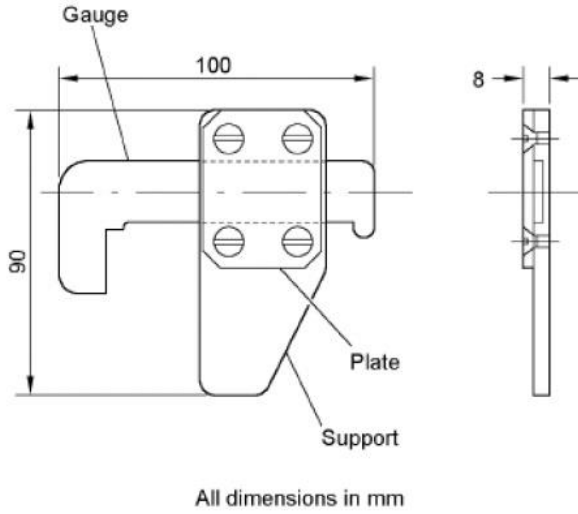


Figure 4: Flange slope [4]

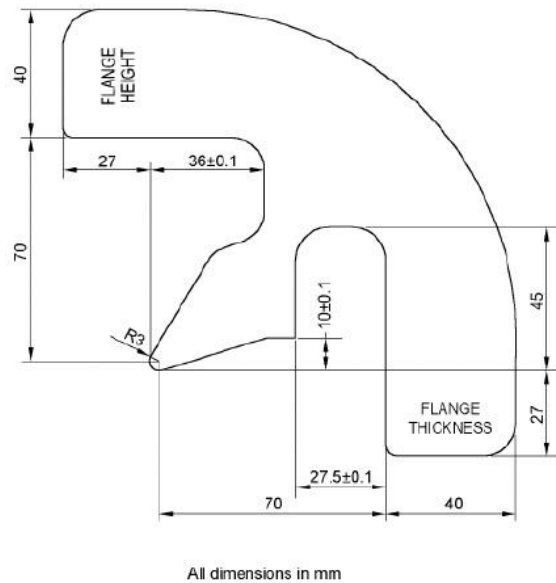
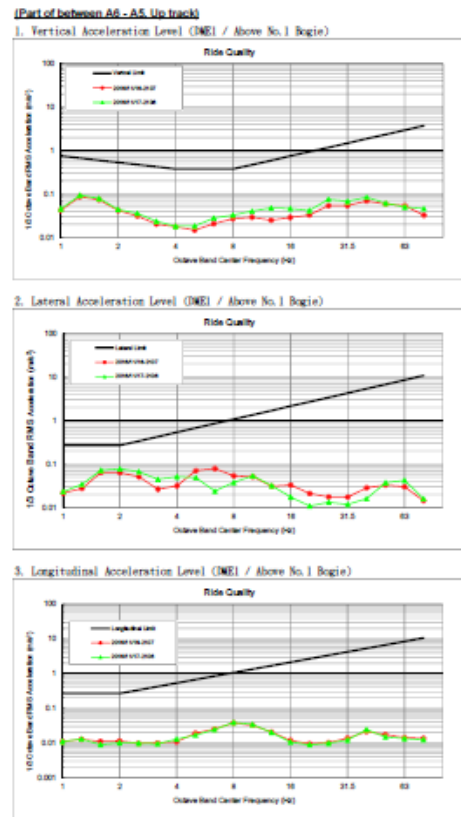
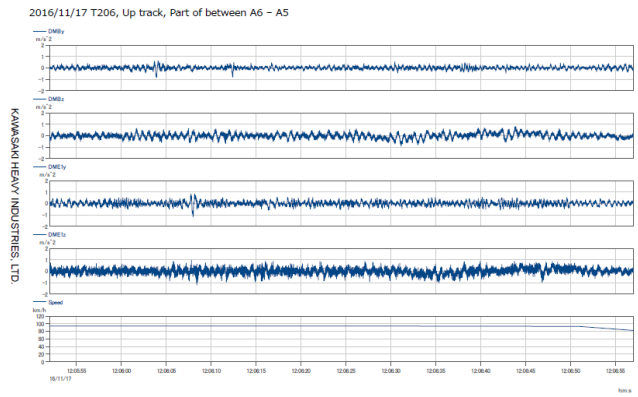
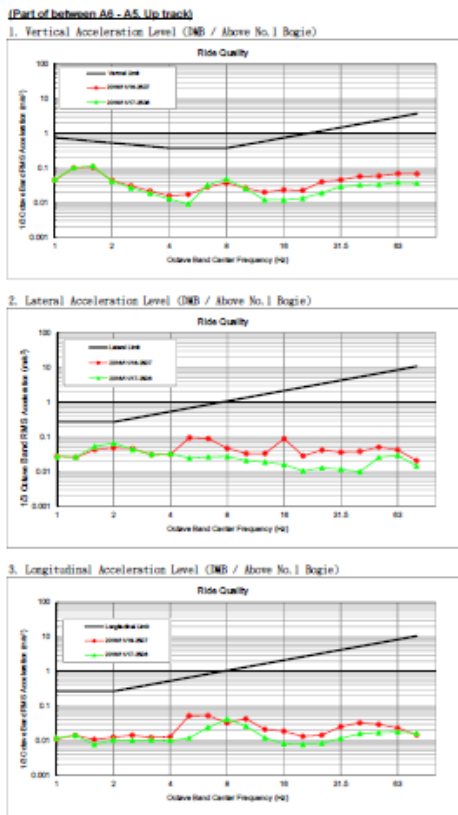


Figure 5: Flange thickness and height [4]

As shown in Table 3, the ride quality of the 2507 and 2506 on the A5-A6 upward track (The ride quality) and Table 4 are the X, Y, and Z axis acceleration waves (train wave) and train speed.

Table 3: The ride quality of the 2507 and 2506 on the A5-A6 upward track (DME1 + DMB)





Analysing the ride quality, XYZ axis acceleration wave, and train speed data curves, it was found that the experimental group and the control group had much greater jitters; the trains were returned to the main repair shop, and the trains in accordance with the above-mentioned steel wheels were used. Measurements, as shown in the photo in Figure 6, show the wheel treads of the DME1 and DMB of the T207 and T206. The T206 wears about 0.5 to 1.5 mm, and the T207 wears about 1.5 to 2.5 mm.

Table 4: X-, Y-, and Z-axis acceleration waves (train waves) and train speeds of the 2507 and 2506 in the upward tracks of A5-A6

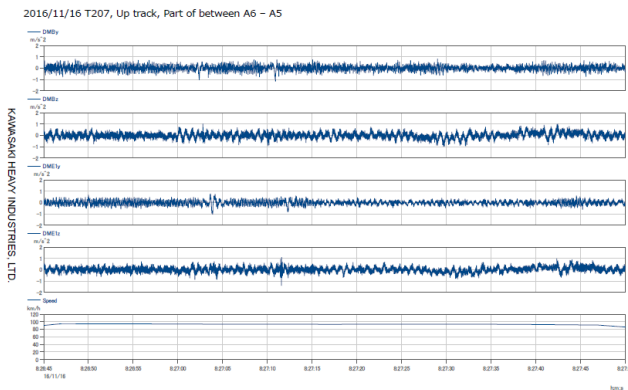


Figure 6: T206 and T207 steel wheel measurement

After the measurement, it is found that the wear contour of the wheel contour is concave in the center, as indicated by the red line in Figure 7. The curve of the arc is not flat, and it is judged that the wheel turning error occurred as shown in Figure 7.

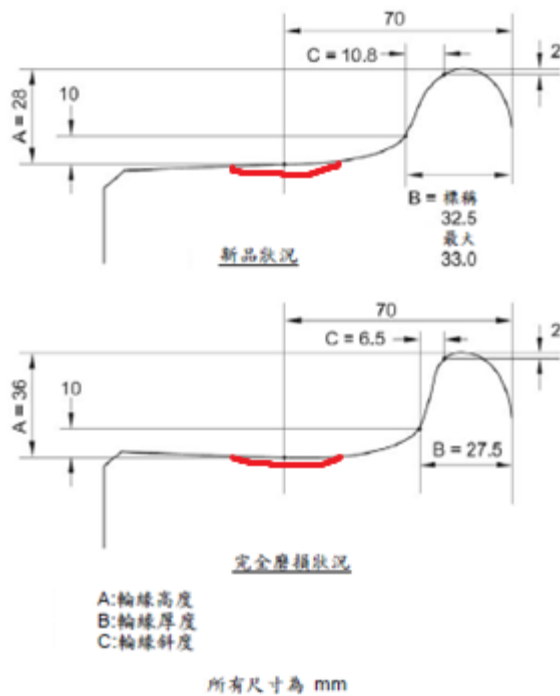


Figure 7: Concavity of wheel contour

### III. Results

Because of this [6], the Taoyuan MRT route is tortuous, and the body is often deflected, which causes the wear arc of the steel wheel to be abnormal. In addition, during the turning process, the difference between the diameter of the steel wheel between the bogie and the bogie was ignored, and various factors caused the train to shake in the high-speed driving section. The flatness of the opposite rail tread will also affect the degree of wear of the steel wheel, so the damage of the steel wheel should be checked visually [7], as shown in Figure 8.

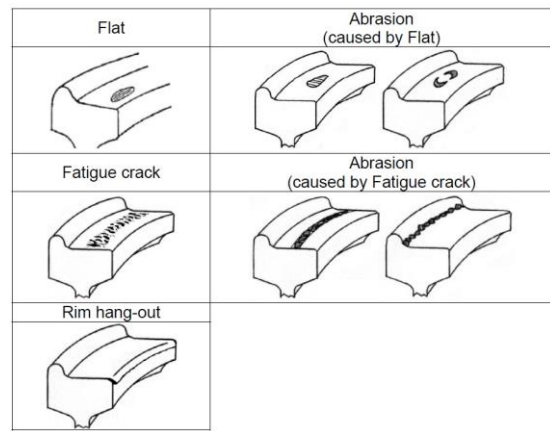


Figure 8: The main legend of wheel damage [7]

This is like we mount a deformed tire on a car. When driving on a highway at high speed, the tire has a severe vibration due to out-of-roundness. The vibration is transmitted back to the shock absorber and back to the car body. Electric vehicle and car vibration return situation is similar, but the difference is the suspension system. The electric vehicle's shock absorber system consists of a primary suspension and a secondary suspension air spring. The secondary suspension air cushion spring is mainly used to automatically adjust the vehicle height and balance the inclination of the vehicle body. The main suspension is mainly composed of a damping spring between the axle and the bogie frame. (Figure 9) [8]

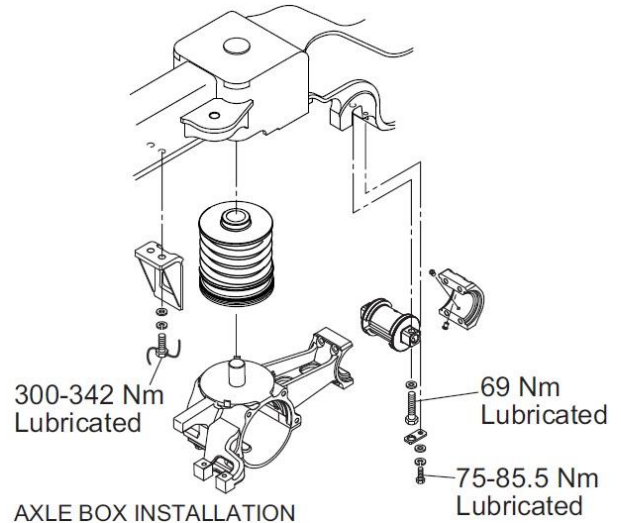


Fig. 9: Main suspension spring [8]

Therefore, when the fluctuation of the steel wheel is transmitted back to the main suspension, the main suspension does not have a damping mechanism like a car suspension. In contrast, almost 100% of the vibration is transmitted back to the vehicle body, causing a severe jitter at the high speed of the electric vehicle.

## IV. Conclusions & Contributions

Taoyuan MRT's track and earth field inspected the top shape of the track tread in the high-speed section, especially the A6-A5 upward track. No correlation found in orbital wave wear. The vibration generated by the system is mainly caused by the excitation of the running wheels (Excitation)[6], which will affect vehicle speed, generate operating noise, cause train delays, and increase operations invisibly loss. Because it is a new operating route, do not neglect the work of track leveling. Track irregularity is the main source of excitation. Track leveling work should be done in time and early. The radian of the steel wheel exceeds the specified radian [4], the difference between the diameter of the steel wheel of the bogie and the bogie of the same car is too large [4], and the difference of the diameter of the steel wheel of the bogie of the car and the car is too large [4]. The train has begun the six-year inspection and overhaul phase, and the main suspension consumables such as bolster rod buffer rubber, axle box rod rubber, and spring seat should be replaced immediately if they are worn out. [9]

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