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RESEARCH ON TEST METHOD OF ABNORMAL PASS BEHAVIOUR OFAUTOMATIC INSTRUMENTS FOR WEIGHING ROAD VEHICLES IN MOTION

Shen Dongbin[1], Ma Kun[2], Liu Ping[3], Wang Lianfang[4],Zhang Shuai[5], Ma Binghui[6]

Shandong Institute of Metrology, Shandong Province, China,
[1] sdb163@163.com, [2] 18615188897@163.com, [3] 17437140@qq.com, [4] 18553159197@163.com,
[5] 18615188830@163.com
Zhejiang Institute of Metrology, Zhejiang Province, China, 15057186872@163.com

Abstract:
This paper introduces common abnormal pass behaviour of automatic instruments for weighing road vehicles in motion (WIM) and gives the corresponding test method. Common abnormal behaviour of WIM includes "S-line" driving, "static and dynamic" driving, "line pressing" driving, and "cross road" driving.

Keywords: abnormal; pass; behaviour; WIM

1. INTRODUCTION

WIM is often used to provide truck weight and vehicle type data for overload inspection of highway transportation management. On the highway, generally, two to three or more WIMs are installed at the same point to form a weighing system [1]. Physical division cannot be realised between each WIM, and some trucks often pass through the WIM in an abnormal way. In this case, it is necessary to test the accuracy of the weighing system composed of WIM [2]. Refer to OIML R134-1 A.9.3.2.4.1 "Test of operating speed interlock" [3], we give the test method of abnormal pass behaviour.

2. DESCRIPTION OF THE WORK

Taking the weighing system composed of three WIMs as an example, we list the four most common abnormal overbalance behaviours, which are "S-line" driving, "static and dynamic" driving, "line pressing" driving, and "cross road" driving, as shown in Figure 1 to Figure 7. We choose a six-axle articulated trailer. Other types of reference vehicle can refer to this method. When the vehicle passes, we record the indication of the tested dynamic truck scale and calculate the error according to R134. The percentage error calculation of reference total vehicle weight is shown in equation (1) [1], [4].

$$E = \frac{(\overline{VM} - VM_{\mathrm{ref}})}{VM_{\mathrm{ref}}} \times 100\ \% \tag{1}$$

2.1. "S-line" driving test

The reference vehicle first runs in a straight line on line 2 at a speed of about 10 km/h. As shown in Figure 1, when the first axle of the vehicle approaches the platform on line 2, the front three axles of the vehicle turn to the right (in the direction of line 3). After the front three axles pass the platform, the rear three axles turn to the left (in the direction of line 1) to pass the platform [1], [5].

A total of three tests are conducted. Take the average of the three displayed values as the vehicle weight indication $\overline{VM}$, and calculate the relative error E according to equation (1).

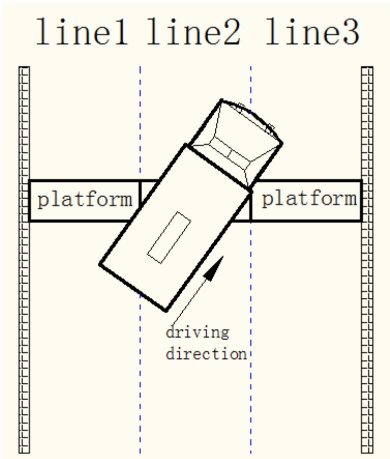

Figure 1:"S-line" driving

The S-line test in the other direction can also be carried out by turning left in the front three axles and turning right in the rear three axles, as shown in Figure 2.

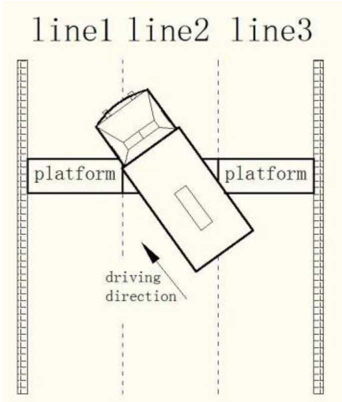

Figure 2: “S-line” driving

2.2. “Static and dynamic” driving test

The reference vehicle initially passes the platform at a speed of about 30 km/h. When the first axle passes, the second and third axles decelerate to 5 km/h. When the fourth axle is pressed on the platform, the vehicle speed drops to 0 km/h, the rear three axles stand still on the platform for about 60 s, and then gradually accelerate through the scale platform, as shown in Figure 3 [1], [6].

A total of three tests are conducted. Take the average of the three displayed values as the vehicle weight indication $\overline{VM}$, and calculate the relative error E according to equation (1).

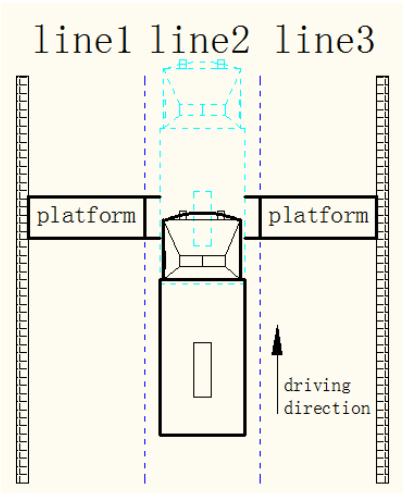

Figure 3: “Static and dynamic” driving

2.3. “Line pressing” driving test

As shown in Figure 4, the left wheel of the reference vehicle passes in a straight line at a speed of 30 km/h along the separation line of line 1 and line 2.

A total of three tests are conducted. Take the average of the three displayed values as the vehicle weight indication $\overline{VM}$, and calculate the relative error E according to equation (1).

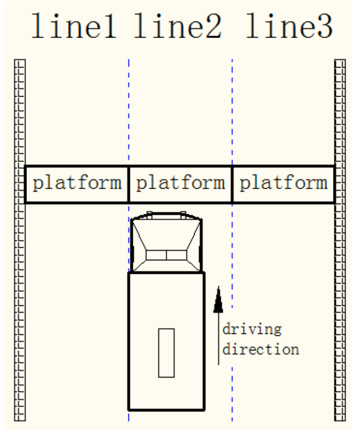

Figure 4: “Line pressing” driving

Another way is that the right wheel of the reference vehicle passes along the separation line of line 2 and line 3, as shown in Figure 5.

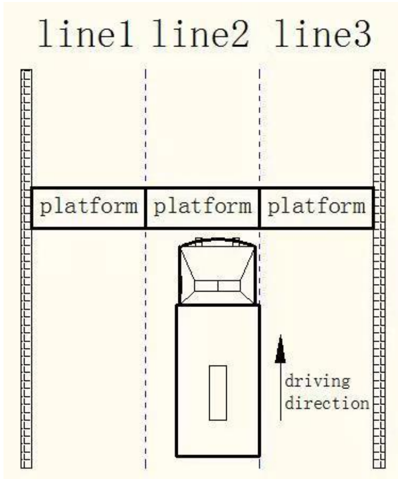

Figure 5: “Line pressing” driving

2.4. “Cross road driving” driving test

As shown in Figure 6, the left axles of the reference vehicle are within the line 1 area, and the right axles are within the line 2 area. The reference vehicle passes through in a straight line at a speed of about 30 km/h.

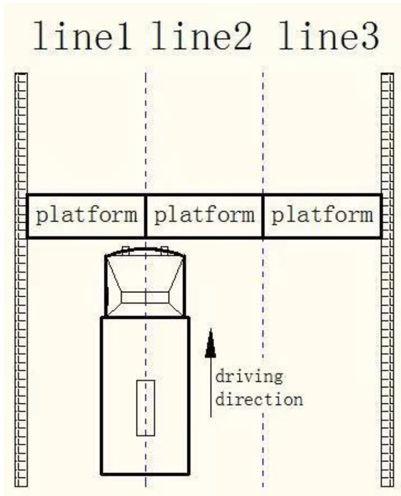

Figure 6: “Cross road” driving

Another way is that the left axles of the reference vehicle are within the line 2 area, and the right axles are within the line 3 area, as shown in Figure 7.

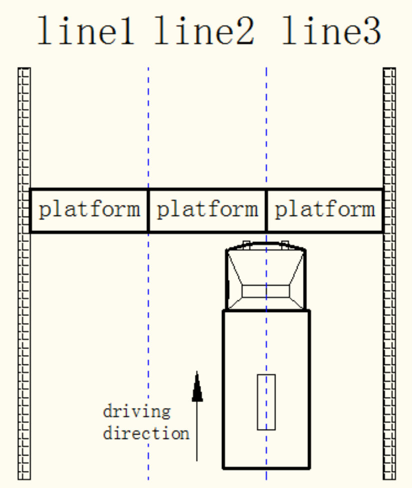

Figure 7: "Cross road" driving

3. EXAMPLE

Since 2020, we have been using these methods to test the dynamic truck scale system. For example, last month, we tested a system composed of three dynamic truck scales. The three identical WIM information is shown in Table 1. In Table 1, *d* means scale interval, i.e. "value expressed in units of mass for weighing-in-motion that is the difference between two consecutive indicated or printed values" [3]; Class means accuracy class of vehicle mass - if class is 5, it means maximum permissible error (*MPE*) is ±2.5 % of $VM_{\text{ref.}}$ [7].

Table 1: WIM information

ID	*d* / kg	Max / t	Class (vehicle mass)	*MPE* / kg	v_{max} / km/h
1	50	50	5	±1 150	60
2	50	50	5		60
3	50	50	5		60

The main sources of measurement results uncertainty include: the repeatability of each set of three tests; resolution of WIM; conventional true value of vehicle mass; fuel consumption of reference vehicle; instability of vehicle running speed. Test data and uncertainty of measurement results are shown in Table 2.

Table 2: Test data and uncertainty

Test type	$\overline{VM}$ / kg	VM_{ref} / kg	*E* / %	U_{rel} k = 2 / %
normal driving	45 850	46 120	-0.59	0.48
S-line 1	44 750		-2.97	0.78
S-line 2	44 450		-3.62	0.79
static and dynamic	45 150		-2.10	0.65
line pressing 1	45 350		-1.67	0.62
line pressing 2	45 250		-1.89	0.64
cross road 1	44 350		-3.84	0.73
cross road 2	44 250		-4.05	0.71

It can be seen from Table 2 that during normal driving, the weighing error of the dynamic truck scale is less than *MPE*, and during abnormal driving, the weighing error becomes larger or even exceeds *MPE*. The influence of several abnormal driving behaviours on *E* is different. "S-line" and "cross road" driving cause that some vehicle weights are not weighed by the weighing platform of line 2, and the weighing error is negative and greater than *MPE*. Relatively speaking, "static and dynamic" and "line pressing" driving have little influence on the behaviour symmetry. Although they also lead to larger errors, they do not exceed *MPE*.

4. SUMMARY

We have applied this method to test more than 50 sets of WIM systems. Facts have proved that this method is conducive to manufacturing enterprises to improve the ability of products to deal with abnormal overbalance, and traffic managers can better master the measurement performance of WIM system [8].

At the same time, we hope R134 can consider and pay attention to the above abnormal weighing conditions and enrich the existing abnormal weighing test types and test methods (A.9.3.2.4.1).

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