

Analysis of Accuracy Affecting Factors of Off-Site Law Enforcement Equipment

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Abstract. Aiming at the problem of overload and overload transportation of highway freight which has been forbidden repeatedly, this paper analyzes the causes, expounds the harmfulness of overload and its control methods, introduces the composition and principle of off-site law enforcement system, analyzes the key factors affecting the accuracy of measurement results and carries out test verification, which provides the improvement for off-site law enforcement system. Draw lessons from.

1. Introduction

Highway transportation has the advantages of flexibility and flexibility, which can meet the transport requirements of different kinds of goods to the maximum extent. It has been widely used in China's economic construction and meet the material needs of the people. Before the middle of 1990s, overload and overrun transportation were very rare. The Highway Law and the Regulations on the Administration of Over-run Transportation Vehicles on Highways are strictly prohibited. However, with the continuous improvement of transport costs, the fierce competition in the transport market and the legal system have led to the phenomenon of overloading and over-run transport becoming more and more serious [1]. Overrun is generally considered to be the length, width, height and quality of freight vehicles exceed the specified limit. According to data released by the Ministry of Transportation, the damage caused by 10% overload of trucks will increase by 40%, and the damage caused by a double overload of trucks will be the same as that caused by 16 non-overload motorcades. For roads that have been in service for more than 10 years, if the vehicles on the roads are overloaded twice, the service life of the roads will be reduced by 90%. Among them, more than 70% of traffic accidents are caused by overloading, more than half of road traffic deaths and vehicle overloading directly across the line. It can be seen that overloading and exceeding limit are the "first killer" and "culprit" of bridge and tunnel safety, seriously damaging roads and bridges, seriously disrupting the order of the transport market, causing vicious competition, disrupting the national road maintenance fees and road and Bridge toll policies, reducing the efficiency of highway use, pollution of the environment and so on [2-3].

At present, the off-site law enforcement system (hereinafter referred to as the "system") is generally used as the technical equipment for the control of supersonic, but its accuracy is still not well evaluated. In order to improve the weighing accuracy and reduce the interference error, it is necessary to understand the source of weighing error thoroughly, so as to reduce or eliminate the irregular over-



weighing motion feeding of vehicles. The interference error and nonlinear change caused by the weighing system.

2. Means of governing technology

At present, the super-technical means of highway management in China are mainly divided into manual low-speed overload detection system and low-precision high-low-speed detection system. Because of the long route and the great mobility of motor vehicles in expressways, national/provincial highways and bridges, only manual inspection has been adapted to the development of highway traffic safety management situation. . It is an important means to control overload, prevent road traffic accidents and protect the safety of roads and bridges to adopt the off-site law enforcement system to ensure the normal running of vehicles. Products are generally based on ASTM E1318-09 (2017) Atandard specifications for highway weigh-in-motion (WIM) system with user requirements and test method, OIML R 134-1 Automatic instruments for Weighing Road vehicles in motion and measuring axle loads in Edition 2006 International standards, and domestic GB/T 21296-2007 dynamic public Road Vehicle Automatic Weighing Instrument, Beijing Local Standard DB11/T 1374-2016 "Highway Dynamic Vehicle Weighing Equipment Technical Requirements and Inspection Methods".

2.1. System composition

The off-site law enforcement system of highway overload and overload is a dynamic law enforcement system suitable for multi-working conditions. It can realize dynamic weighing of various vehicles, detection of vehicle length and width, license plate recognition, short-time video, real-time video monitoring, automatic production of law enforcement documents. It is suitable for off-site monitoring of over-limit and overload of various types of vehicles and wide speed range, especially for comprehensive monitoring of over-limit and overload of highway bridges and culverts with large traffic flow and complex vehicle types. At present, the equipment manufacturers and market share in 2012: Metro, Toledo (12%), Wanji Technology (31%), Beijing Zhongshan (8%), Zhengzhou Hengke (7%), Shandong Drutai (6%) and Henghua Technology, etc., generally can detect the information of passing vehicles within the speed range of 0-200Km/h to ensure that the speed range of 0-80km/h said. The accuracy is above or equal to 5%, meeting the national dynamic ten level standard. The system is generally composed of weighing detection equipment, data acquisition device, industrial control computer, length, width and height measuring device, video monitoring system, license plate recognition system, length and height measuring acoustooptic alarm and information center.

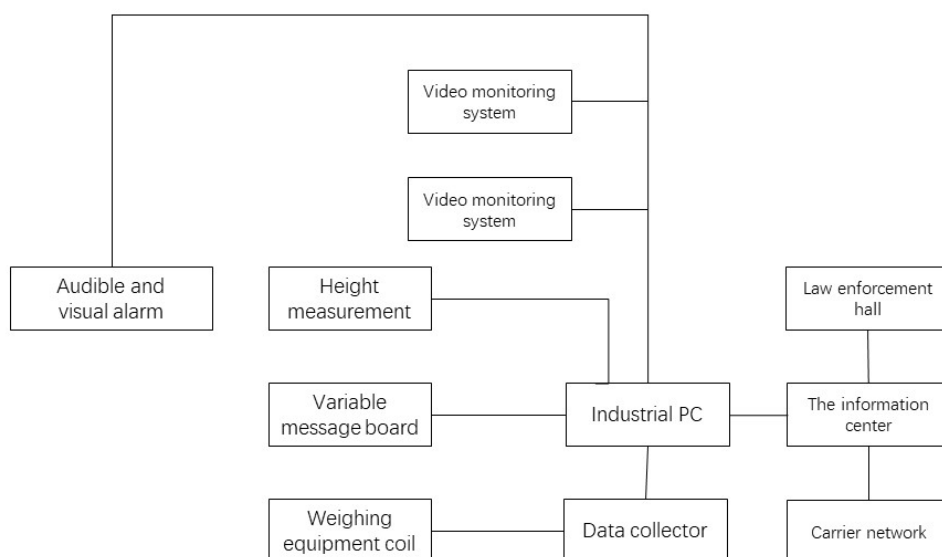


Figure 1. Composition and principle of typical system

2.2. *Page Numbers system workflow*

The workflow of off-site law enforcement system is divided into 4 steps: monitoring, discovery, recognition, storage and display. The weighing sensor divides and weighs each passing vehicle, displaying information collection location, date and time, speed, axle number, axle spacing, vehicle type, axle weight, axle weight, axle group weight, vehicle total weight, Lane number, vehicle acceleration, Over-gauge information, Over-gauge percentage, vehicle weighing waveform, grab, etc. Take the equipment number, vehicle picture, license plate number and so on. When the over-weight vehicle appears, the industrial control computer immediately sends the alarm signal to the information center, and sends the over-weight signal to the industrial control computer. The IPC controls the license plate recognition device to shoot panoramic photos of the target vehicle and identify the vehicle license. The industrial control computer stores and uploads the overweight information and photos of the target vehicle, and controls the sound and light alarm to alarm. The information board displays the license plate and overweight data of the overweight vehicle and prompts the underpass.

2.3. *Classification of weighing methods*

(1) quartz type

The quartz type mainly adopts the quartz sensor imported from Kistler, Switzerland. The overall structure of the quartz sensor is like a long I-beam. The difference is that the web of the I-beam is hollow section. The hollow is a rectangular through-hole formed by two parallel planes of the upper and lower flange of the parallel I-beam. The principle is that the weight of the wheel is transmitted to the sensor body through the bearing surface. The quartz wafer in the body produces a charge proportional to the load of the wheel due to piezoelectric effect. The charge amplifier converts the analog voltage into analog voltage, and then converts the analog signal into digital signal through the converter. Finally, the analog signal is converted into digital signal through the embedded computer and its special software. The weighing result is obtained. In the process of using, regardless of the speed of the vehicle, the quartz sensor can maintain the same accuracy and is not affected. Quartz sensor is a rigid structure, the measurement process does not rely on deformation, no mechanical wear, no deformation caused by material aging, has good long-term stability and life [4-5].

(2) plate type

The principle of flat-panel weighing system comes from the mature railway track technology. The weighing part is composed of flat-panel outer frame and custom-made sensor. The sensor is resistive, and the sensor is interchangeable and customized. When the axle loads are applied on the panel, the shear T-beam installed below the panel produces micro-deformation. The shear force produced by the deformation is measured by a special unknown shear sensor installed outside the main beam. The axle load is finally calculated. As shown in the following figure. The bending plate weighing technology has been used in expressway for a long time, and the technology is very mature. Bending plate is a kind of integral sensor, without mechanical force taking structure, the vehicle passes through the sensor completely, and the wheel pressure acts directly on the sensor, so it has a very long service life. Bending plate weighing technology is a high-speed weighing technology. Its speed range is 0-200 km/h. The outer layer of bending plate is completely sealed by vulcanized rubber. It is incomparable with mechanical weighing equipment and has very high corrosion resistance. The wide temperature range of the bending plate sensor can also completely satisfy the service environment of the toll station. The bending plate sensor is an integral sensor, and the equipment is fully sealed and installed, thus completely eliminating the disturbance caused by silt to the normal use of the equipment. The sensor (sensing device) is free of maintenance and greatly reduces the maintenance cost of the equipment. The foundation of the bending plate sensor is shallow, and the installation only needs to excavate a 10 cm deep installation groove on the original pavement. The construction is simple and fast, and the construction is convenient and the cost is low in the future pavement maintenance. However, bending plate sensing technology also has some shortcomings: the equipment price is high, and the initial investment is large. The controller of the bending plate sensor is of poor quality and needs to be improved. The sensor is manufactured abroad, with high cost, poor maintenance and service.

(3) array type

The array type and the traditional weighing are calibrated by several sensors. The narrow strip sensor is a kind of resistance strain type weighing sensor made of alloy steel. Its repeatability reaches 0.1% FS. The rated load (wheel load) is 15t, and it can be in the range of (-40-80) °C. The utility model has a life span of more than 20 million times, and can be used in the water immersion condition and mounted on the shallow surface. The system can detect the axle load, total weight, vehicle type, license plate number and over-limit information of passing vehicles in the speed range of (0-80) km/h. The weighing accuracy is (+ 2.5%).

3. Analysis of factors affecting system accuracy

In the vehicle dynamic weighing technology, the latest hardware technology of sensor plays an important role. With the use of the latest hardware technology, the accuracy of vehicle dynamic weighing, vehicle speed, engineering cost and other aspects have been improved [6]. However, the software technology based on the processing of axle load signal produced by the system also plays a very important role in the design of dynamic weighing algorithm, that is to say, it is necessary to study the vehicle dynamic weighing technology by using the mathematical model of the measuring system and the appropriate algorithm. In dynamic weighing, the vehicle passes through the weighing platform at a certain speed. Not only does the tire work on the weighing platform for a very short time (within hundreds of milliseconds), but also the force acting on the weighing platform has many factors, such as vehicle speed, vehicle vibration, road excitation, tire force, etc [7-8]. It can be said that the real axle load is often submerged in a variety of interference, which makes it very difficult for high accuracy dynamic weighing.

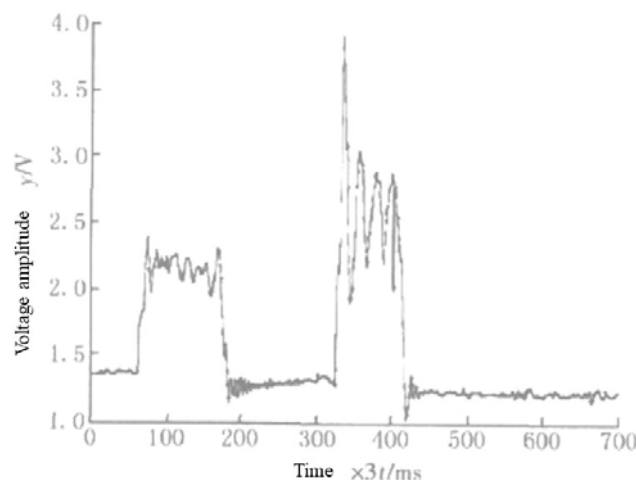


Figure 2. Signal of axle load generated by sensor

Fig. 2 is an axle load signal generated by a weighing sensor when two axles pass through a scale. As can be seen from the diagram, when the vehicle touches the weighing platform, it will produce a shock vibration on the platform, and gradually presents a phenomenon of attenuation. The higher the speed is, the steeper the front rising section of the axle load signal is, the greater the impact vibration on the platform is, and the farther the final value of the rising section deviates from the true value of the axle load. Therefore, in the case of low speed, the measured value of the sensor can be regarded as the axle load value directly. However, with the increase of vehicle speed, the measurement error will increase. Finally, it will not meet the accuracy requirement of measurement.

Sometimes it is found that the last peak value of the axle load signal is larger than the one in front of it, which destroys the attenuation law of the impact vibration on the platform. The reason for this phenomenon is that the wheel sometimes produces additional impact when it leaves the platform, so it

is often necessary to remove the impact of the off-stage impact in signal processing [9-12]. In dynamic weighing, the axle load signal produced by the sensor is accompanied by various disturbances. Generally, appropriate algorithms are used to improve the measurement accuracy. The commonly used algorithms include maximum measurement, arithmetic average measurement, neural network method and system identification method based on parameter estimation [13].

4. Test validation

According to the Verification Regulation JJG 907-2006 "Dynamic Highway Vehicle Automatic Weighing Instrument", the test object is manufacturer A (narrow strip) and manufacturer B (flat plate). The test section is S304 Leidian section of Deqing County in Huzhou City, Zhejiang Province, and G104 Shangbai section of Deqing County in Huzhou City, Zhejiang Province. The standard car is a 15 earthwork vehicle (standard value 26670 kg, 28250 kg) and a 157 vehicle (standard value 40210 kg). The standard value is measured by a class III static scale. In the test, the standard vehicle is 5 km/h, 10 km/h, 15 km/h, 20 km/h, 30 km/h, 40 km/h, 50 km/h and 60 km/h respectively (the similar speed can be regarded as the same speed). The vehicle passes through the weighing area uniformly and repeats the measurement three times consecutively. The maximum error of the relative indication value is the measurement result, as shown in Table 1. The same velocity

Table 1. Repeatability test results of off-site law enforcement system

Speed (km/h)		5	10	15	20	30	40	50	60
error for the same velocity standard value /t	28.25	1.24%	1.52%	1.42%	0.32%	0.74%	2.19%	2.65%	3.96%
	26.67	-0.79%	-0.11%	2.32%	1.09%	0.41%	-0.64%	2.51%	1.61%
	40.21	1.67%	2.88%	-0.42%	1.39%	1.14%	1.12%	2.54%	
B	28.25	-4.07%	-9.38%	2.12%	0.53%	-0.71%	-1.95%	-2.12%	-11.15%
	26.67	-4.20%	-10.01%	-0.45%	3.67%	-0.07%	-2.32%	-5.32%	-7.39%
	40.21	-5.37%	-4.75%	-5.00%	-0.40%	1.09%	-0.65%	1.84%	

Note: the risk of driving 157 vehicles in 60km/h is high, so it is not measured at this speed.

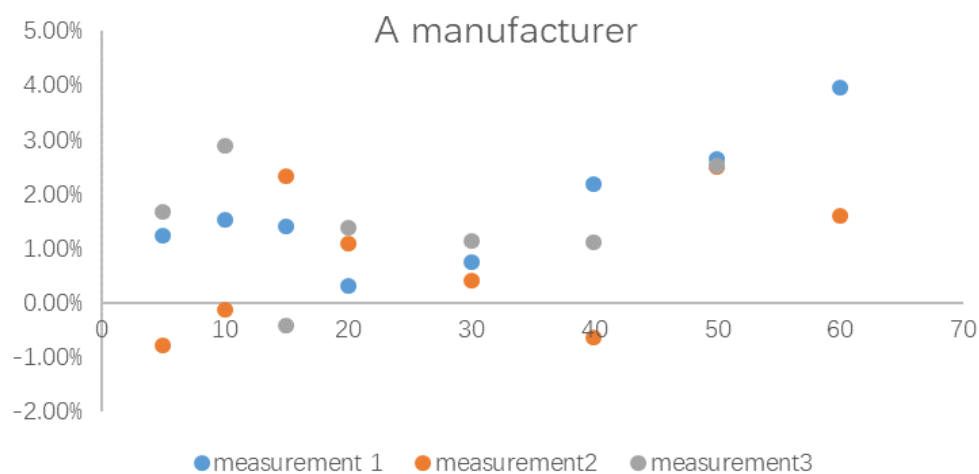


Figure 3. Dot matrix diagram of test results for A manufacturers

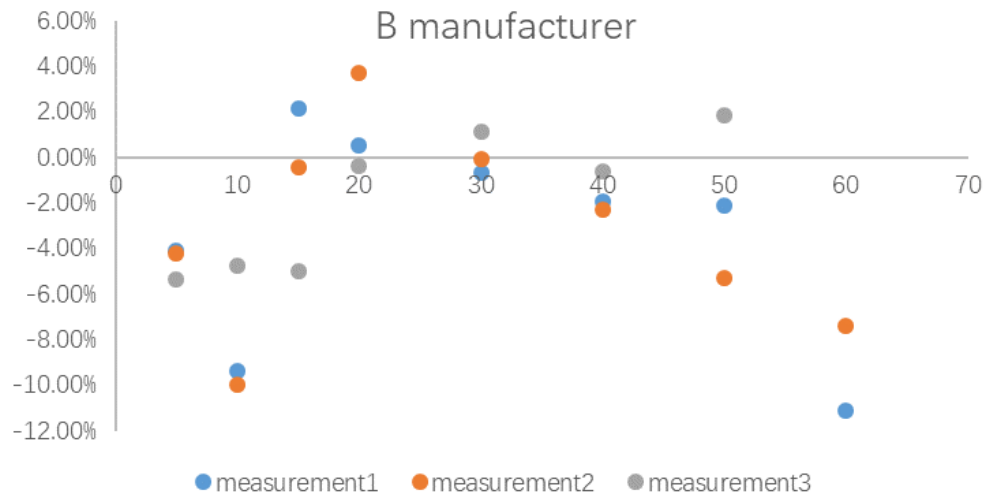


Figure 4. Test results of B manufacturer

From tables 1, 3 and 4, it can be seen that the measuring error of the equipment of manufacturer A is within (5-50) km/h, and the measuring result is less than 2.5%, which can better evaluate the equipment. When the vehicle speed is 60 km/h, the measuring error is obviously increased. The measurement error of B manufacturer's equipment is less than 5.0% when the vehicle speed is (15-50) km/h. When the vehicle speed is (0-15) km/h, the measurement result is more than 5.0%. When the vehicle speed is 60 km/h, the measurement result obviously exceeds the requirement. When the speed is high or the time is high, the measurement results will be inaccurate and the narrow strip is better than the flat plate.

5. Summary

Off-site law enforcement system is an effective new technical means to solve the problem of road overload. Understanding the source of weighing error can reduce or eliminate the disturbance error and non-linear change caused by the irregular over-weighing motion of vehicles. In addition to the application of fast-response high-precision weighing sensors and practical, high-speed, high-precision dynamic data processing software, it is also necessary to improve the standard procedures on the basis of the accumulation of large amounts of data, improve the monitoring means and system management.

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