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Analysis of the design versions of auxiliary verifier for weight-free verification of large-load platform railroad scales

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Abstract
Two design versions of auxiliary verifier VNKU-60 for weight-free verification of large-load platform railroad scales are compared. Both versions are new in their designs and were elaborated with the participation of the author in the course of performing the research work. Individual verification schemes of simultaneously loading the standard weight measuring sensors embedded in the VNKU-60 design and the duty sensors of load carrier with ballast weight via a weight-transmitting device using hydraulic jacks for both designs of VNKU-60 are proposed, respectively. On the basis of analysis of the advantages and disadvantages of each version of VNKU-60 design the recommendations on its further use in present-day conditions were given.
Keywords: NON-AUTOMATIC WEIGHING CALIBRATION DEVICE, AUXILIARY VERIFIER, LOAD CARRIER, WEIGHT-TRANSMITTING DEVICE, RAILROAD SCALES, WEIGHT-FREE VERIFICATION, CALIBRATION OF LARGE-LOAD SCALES, STANDARD WEIGHT MEASURING INSTRUMENT

Large-load platform scales are the most common means of instrumentation when performing commercial transportation by railroad. Technical and metrological characteristics of the scales shall meet the requirements [1, 2]. Verifying (calibrating) the scales shall be performed in accordance with the requirements [3]. According to these requirements the basic method of verifying of large-load stationary platform railroad scales is directly loading the scale platform with M_1 class standard weights 2 tons in mass. The total mass of weights, which is required during verification must be multiple of the largest weighing capacity range (LWCR) of loading. The weights to the scale platform are delivered by a weight-verification car. In the course of verifying it is necessary to perform the multiple loading of the scale platform that requires moving the large masses of weights.

Applied problem for solution of which the research was directed

The problem is the lack of weight-verification cars (WWC), most of which were made in Soviet times and are obsolete. Owing to this, the deadlines of inter-verification period are broken, that results in temporary suspension of operating the weighing equipment and production timeouts. It leads to great losses that industry enterprises bear in case of waiting their turn.

Thus, for significant reduction in operating costs and time for performing the verification of large-load scales, devising a new method of weight-free verification and relevant standard instrument that is intended for designs of platform railroad scales available in operating to avoid additional financial costs for their modernization is pressing and economically expedient.

Analyzing recent achievements

Well-known Russian technique of weight-free verification for large-load platform railroad scales [4] in which loading the scale platform not with weights or ballast masses but with various loading mechanisms measuring load forces by means of the standard sensors embedded in the device is proposed, and the results are compared with readouts of the duty sensors of the load carrier.

Many patents were issued to various designs of the loading device. As a variant, loading the scale platform by means of hydraulic cylinders is proposed. In this direction, a number of well-known industrial companies have fulfilled a modernization of the design of platform scales, which includes a special frame binding and strengthening of the foundation, which allows making a rest for the loading device installed onto the scale platform. In some designs a rope that is attached to the foundation is run through the hole at the very scale platform. The winch that is placed on top of the scale platform pulls the rope creating tension force. In other designs of the scales making the placement of the force-measuring sensor of the standard device under the scale platform is proposed, which is far from always possible.

Thus, the above discussed Russian technique of weight-free verification has certain disadvantages. In creating a load force onto the load carrier, a counteracting force is appeared, which leads to a need for a significant strengthening of the scales foundation or a considerable complexity of the very metal structure. These structural complexities led to the fact that the total cost of new platform scales has significantly increased, and applying the well-known method of weight-free verification for the existing scales has become absolutely impossible. However, the complexity of the scales design which must withstand a counteracting force to the loading device of several tens of tons, which is appeared according to Newton's third law, led to the fact that the Russian method of weight-free verification has become widely used neither in Russia nor in Ukraine. In substantiated cases it can be used for diagnosing the technical state or adjusting the individual components of a weighting terminal. But at present, applying the Russian technique under verification of platform railroad scales is unacceptable. The reason of this consists in the fact that verification officer has not the proper design of the loading device that would create load forces onto the scale platform, which would be adequate to real operating conditions. These circumstances have delayed the wide application of the weight-free verification technique in practice.

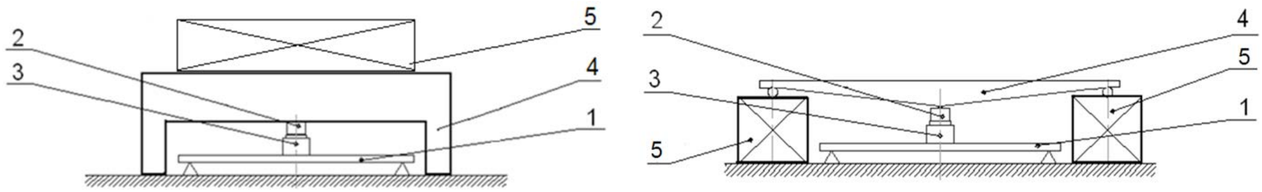
The aim of the research is the elaboration of new design versions of the loading device for the load carrier and non-automatic weighing calibration device which can be applied for weight-free verification of large-load platform railroad scales.

The subject of the research is the ways of creating of load forces onto the load carrier, which would be adequate to real operating conditions.

Describing the basic material

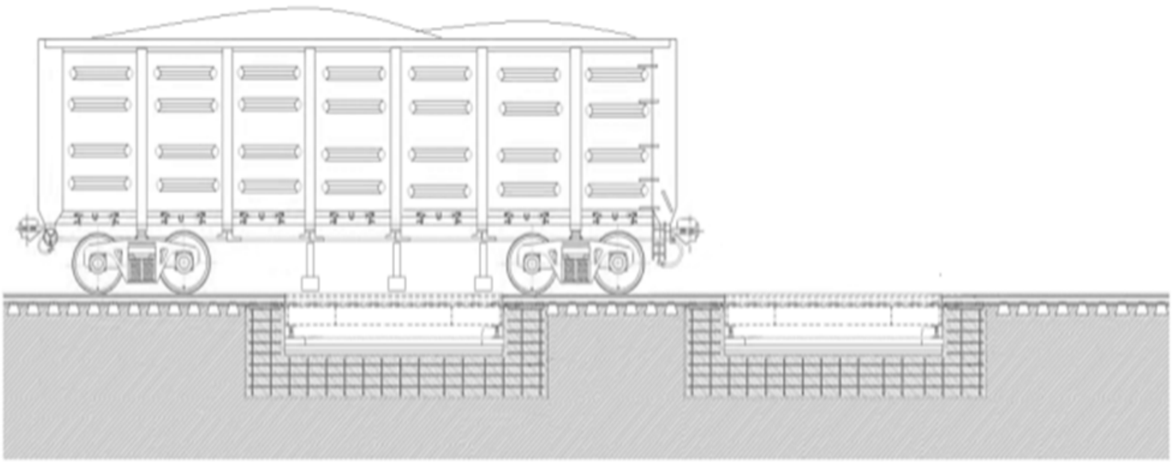
A new auxiliary verifier called 'Non-automatic weighing calibration device with maximum weighing range of 60 tons (VNKU-60)' is proposed for introduction into the verification scheme of weight measuring instruments for verification working standards, which shall replace the weight-verification car outfitted with weights [5]. Proper schemes of loading the load carrier for weight-free verification of the scales using VNKU-60 were elaborated (Fig. 1).

The theoretical prerequisites to the implementation of the assigned task are based on a new method and way of setting of load forces [6] in the full range of loading the scales platform, which are verified by means of hydraulic jacks and ballast weight that is available, for example, a railroad car loaded with something (Figure 2).



a) b)

Figure 1. Versions of loading the load carrier with one great ballast weight (a) or with two small weights (b), where: 1 = load carrier; 2 = weight-measuring sensors; 3 = hydraulic jack; 4 = weight-transmitting device; 5 = ballast weight



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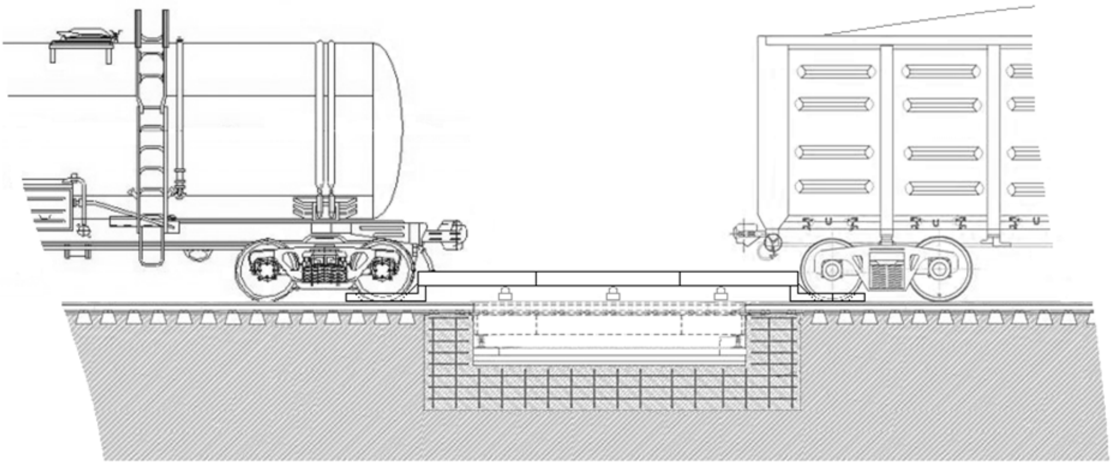


b)

Figure 2. Layout schemes of ballast weight according to load carrier using: (a) one car; (b) two cars, respectively

Verifying the scales using the VNKU-60 auxiliary verifier is carried out by comparison method with loadings with equal values of mass to ballast weight, which are evenly distributed in the full range of weighing, in doing so the calculated values of verification points can mismatch with rounded values from a weights set.

In accordance with these schemes two design versions of the VNKU-60 device were elaborated. **Version 1** of the device [7] for weight-free verification of the scales includes the ballast weight in the shape of one freight gondola car and is made up of six modules grouped in pairs into three separate sections that are spaced at a center-to-center interval of 1700 mm on the rails of the scale platform, which equals to the distance between the side stakes of the body of open-top freight car (Fig. 3).

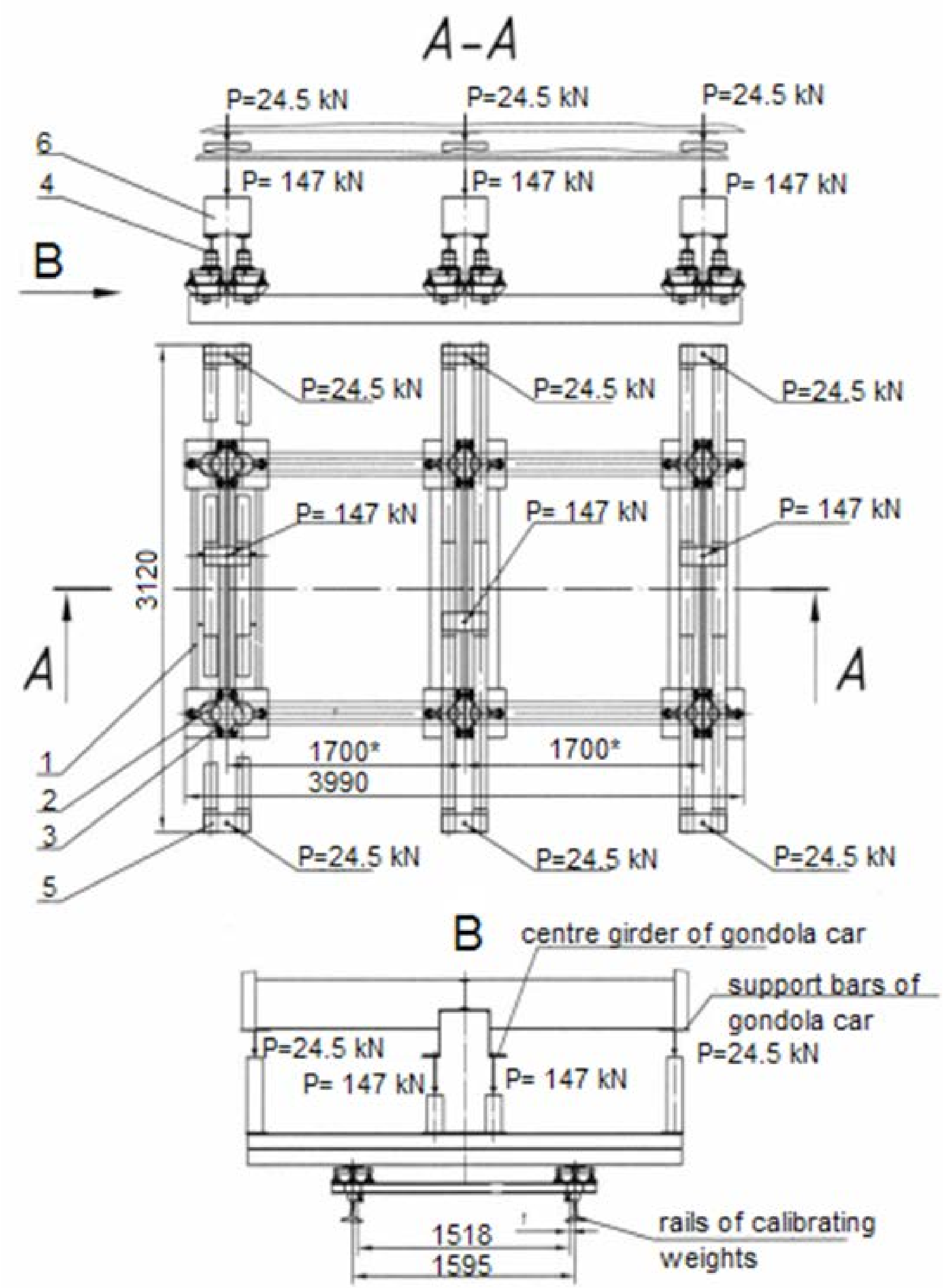


Figure 3. VNKU-60 with scheme of reproduction of load forces onto one section of the scale platform: 1 - load-receiving device; 2 - weight measuring device VP-5; 3 - strain-gage sensor; elements of weight-transmitting device: 4 - built-up beam; 5 - side crosspiece; 6 - central crosspiece

One section of VNKU-60 includes:

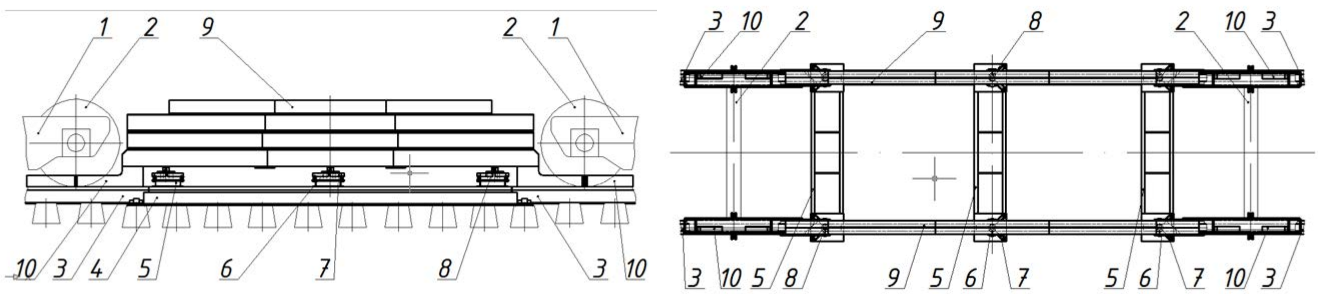
• Loading device consists of three hydraulic jacks that are installed on crosspieces 5 and 6, on side crosspieces 5 two jacks with the maximum force of 5.0 tons (49 kN) are installed, and on central crosspiece 6 the third jack with maximum force of 15.0 tons (147 kN) is installed;

• Weight-transmitting device 4–6 is built-up welded metal structures (crosspieces 5 and 6 and two beams 4), which are located across the rail top, have a length of 3120 mm, respectively, to overall width of gondola car on the side stakes, and which are centered and leaned on the disks of weight measuring devices 2 by their supports;

• Weight-transmitting device 2 (four units) is a set of three standard beam sensors fastened at the receiving disk at an angle of 120° to each other which are located in pairs on two sides through the center of the rail head atop on the slabs of load-receiving device 1;

• Load-receiving device 1 (two beams 1), which is two frame welded metal structures which are fastened across the rail top (to prevent separation of the metal structure of the device from the rail heads during loading, in the bottom of the frame in bounding angle bars two hold-down props interacting with the bottom of the rail head are provided for).

Version 2 of the device [8] for weight-free verification of the scales includes the ballast weight, which is formed with two railroad cars 1 of any type and loaded with cargo of random type according to laid-down rule (Fig. 4).



a) b)

Figure 4. Version 2 of VNKU-60: side view (a); top view (b), where: 1 - railroad cars; 2 - wheelsets of cars; 3 - railroad rails; 4 - load carrier; 5 - weight-transmitting devices; 6 - weight measuring devices; 7 - strain-gage sensors; 8 - loading devices (hydraulic jacks); 9 - load-receiving devices; 10 - clamps for wheels

Wheelsets 2 of the cars are located on rails 3 of the approaching lines beyond of load carrier 4, and on the site of rails located on the load carrier 4 three weight-transmitting devices 5 are installed, which are located in parallel to each other and perpendicularly to the rails of load carrier 4. At each weight-transmitting device 5 two weight measuring devices 6 located over rails 3 of the loading carrier are installed. Each of weight measuring devices 6 contains a set of three standard strain-gage sensors 7. On top of weight measuring devices 6 loading devices 8 (e.g. hydraulic jacks) are installed, which are connected in parallel with a source of pressure. Above the loading devices 8 (hydraulic jacks) along rails 3 of load carrier 4, load-receiving devices 9 are located horizontally, which are made in the shape of a set of beams with connecting elements. Both ends of each load-receiving device 9 content clamps 10 in the shape of forks for rigid attachment of the wheels of abutting wheelsets 2 of railroad cars 1. The sets of beams of load-receiving device 9 and clamps 10 can be made demountable that will assure their use without applying lifting machines.

In the course of verifying, the load forces are initially raised up to the maximum weighing level, and then load is diminished up to the maximum weighing level according to rules that are specified in the datasheet for load carrier by manufacturer. The number of such cycles of loading when verifying load carriers is set according to the current state standard of Ukraine [1]. Thereafter the related results of measuring the load forces obtained from the weighing devices of two types—reference and working ones are analyzed, then measurement error is calculated which is compared with rated one. On the basis of the comparison a conclusion on the suitability of scales for further use is drawn. If the design of platform scales consists of two or more load carriers, then the procedure shall be performed in turn and separately for each of them.

Shortcomings of version 1 [6] that version 2 [8] does not have are as follows:

1. The presence of danger zone when performing the assembly work, which is due to the location of the constituent elements of instrument design in the space between the body of gondola car and railroad rails of load carrier.

2. The presence of limitation on use as ballast weight only one type of railroad car – the gondola car, which is caused by the design features of the very instrument adapted to the features of the constituent elements of gondola car body.

3. The existing design limitations on increasing the maximum load force on the vertical struts and truss rod of gondola car body.

Despite these shortcomings both design versions of the VNKU-60 device meet the Ukrainian technical regulations [9] which were developed on the basis of Directive 2009/23/EU on non-automatic weighing instruments and also requirements to verification standard weight measuring devices [1] in the part concerning auxiliary verifiers. Regardless of the design version the VNKU-60 devices have common technical characteristics as follows:

Largest weighing limit, Max, kg 60,000

Smallest weighing limit, Min, kg 400
Climatic version according to GOST 15150-69
Load module UHL3, °C –20…+ 40
Contl system UHL1, °C –40…+50
External communication interface versions RS232, RS485, CAN
Weighing cycle time, s 20
Voltage, V, Hz 220, 50 ± 20 % ± 15 %
Power consumption, not more than, W 53
Operating temperature range, °C –20…+ 40

They differ from each other only in their overall dimensions and the total number of embedded standard strain-gage sensors. Design version 1 of VNKU-60 has 36 sensors, and design version 2 has 18 sensors. In both versions a power bridge of three ZEMIC H8C beam strain-gage sensors with accuracy class: C_3, C_4, or A_5M is used for measuring tensile forces in the stretch/pinch mode. In version 1 the sensors with a nominal load of 2000 kg are used, and in version 2—5000 kg. In consequence of this, versions 1 and 2 differ in the limits of permissible error of weight measurement. According to the same types of applied sensors, version 1 of VNKU-60 has performance by 20% better on the accuracy of weight measurement in comparison with version 2 (see Table).

Table. Measuring the mass of ballast weight with the help of NPC-60 device

Accuracy class of ZEMIC H8C sensors	Limit of permissible error of weight measurement, kg	
	Version 1	Version 2
C_3	± 25.2	± 31.5
C_4	± 18.9	± 23.6
A_5M	± 15.1	± 18.9

In accordance with the requirements of i. 3.5 and i. 3.7 [1] both versions of VNKU-60 can be used as an auxiliary verifier for verifying platform railroad scales with verification interval e = 50 kg during operation with the limit of permissible error ±2e = 100 kg. But version 1 of VNKU-60 as opposed to version 2, if it is equipped with sensors with accuracy class A_5M, can be applied also during the initial verification of large-load platform railroad scales. But then the design of version 2 is more universal in practical application.

Conclusions

Thus, with the emergence of two design versions of VNKU-60 at the same time their application in verifying or calibrating large-load platform railroad scales without additional financial costs for the modernization of the latter ones has become quite real, which will significantly reduce the shortage of weight-verification cars.

Recommendations for implementation

It is necessary to develop a new technique of weight-free verification of large-load platform railroad scales in accordance with the proposed new versions of loading the load carrier (Fig. 1) taking into account the proposed design versions of VNKU-60.

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