A new design of non-automatic weighing calibration device for weight-free verification of large-load platform railroad scales

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Abstract
The article puts forward to supplement the verification standard weight measuring instruments with a new auxiliary verifier – 'Non-automatic Weighing Calibration Device with maximum weighing range of 60 tons (VNKU-60)' in which hydraulic jacks and ballast weight for applying the load forces on the load carrier are used. Version 1 of the design of VNKU-60 had limitations related to use of only one type of rail car — a 'gandola car' as a ballast weight, into the body of which the construction of the very device was arranged. In this connection version 2 of the VNKU-60 device design has been elaborated, which has turned out universal one, as for its use any types of rail cars fit that are available during verification. In spite of the difference, the author recommends both versions of the VNKU-60 device design for introduction instead of weight-verification cars for weight-free verification for large-load platform railroad scales.
Keywords: NON-AUTOMATIC WEIGHING CALIBRATION DEVICE, LOAD CARRIER, WEIGHT-TRANSMITTING DEVICE, RAILROAD SCALES, WEIGHT-FREE VERIFICATION, CALIBRATION OF LARGE-LOAD SCALES, STANDARD WEIGHT MEASURING INSTRUMENTS

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 large-load stationary platform railroad scales is directly loading the scale platform with M_1 class standard weights 2 tons in mass [4]. The total mass of the weights which is required under 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 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 a 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

A well-known Russian technique of weight-free verification for large-load platform railroad scales [5] 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 of 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 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 a 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.

A new auxiliary verifier that is called 'Non-automatic Weighing Calibration Device with maximum weighing range of 60 tons (VNKU-60)' is put forward to introduce into verification standard weight measuring instruments, which shall replace the weight-verification car outfitted with weights [6] in the course of using the railroad platform scales.

Version 1 of the VNKU-60 design was elaborated for using one rail car of the 'gondola car' type as a ballast weight [7]. In addition to limitations in usage of one type rail car only for verification — 'gondola car' as a ballast weight, version 1 of the VNKU-60 design had other shortcomings:

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

The aim of the research is the elaboration of a new design version of the non-automatic weighing calibration device and corresponding technique of weight-free verification for large-load platform railroad scales for it.

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

Describing the basic material

A new scheme (Fig. 1) and a method (Fig. 2) of loading the load carrier for weight-free verification of scales using VNKU-60 have been worked out.

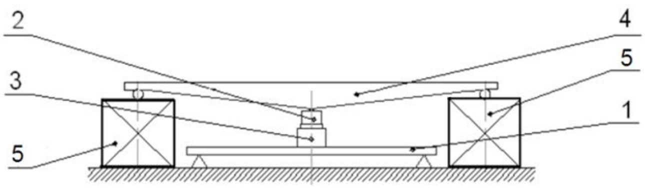

Figure 1. Scheme of loading the load carrier using two ballast weights, where: 1 = load carrier; 2 = weight-measuring sensors; 3 = hydraulic jack; 4 = weight-transmitting device; 5 = ballast weight.

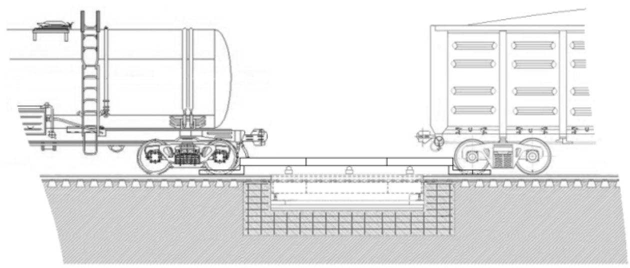

Figure 2. Layout scheme of ballast weight when loading the load carrier

The new version of the VNKU-60 device for weight-free verification of platform scales [8] includes the ballast weight that is formed with two railroad cars 1 of any type, which are loaded with cargo of random type according to laid-down rule (Fig. 3).

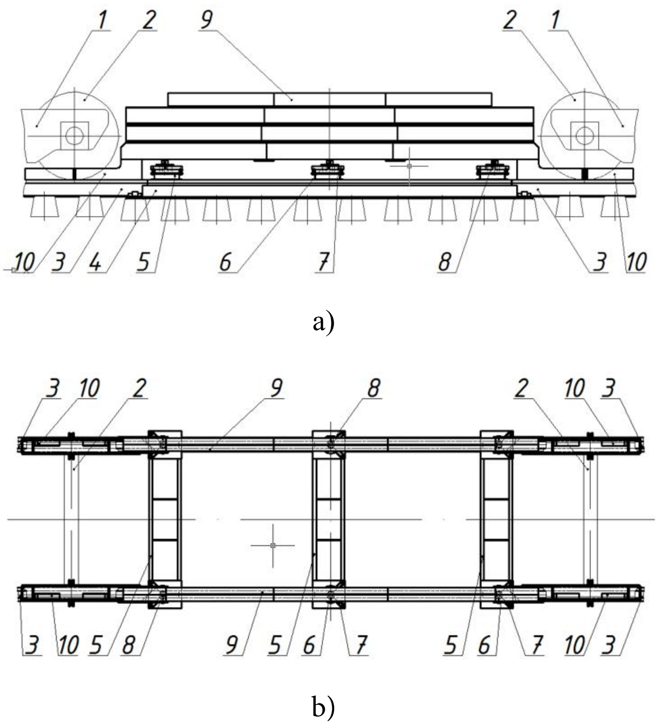

Figure 3. New version of VNKU-60: side view (a); top view (b), where: 1 = railroad cars; 2 = wheelsets of cars; 3 = railroad rails; 4 = load carrier; 5 = weight-transmitting devices; 6 = weight-measuring devices; 7 = strain-gage sensors; 8 = loading devices (hydraulic jacks); 9 = load-receiving devices;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

The proposed device for weight-free verification of platform scales shall be used in the following way (Fig. 3). At the site of rails 3 that pass through load carrier 4 weight-transmitting devices 5 are installed, which are located in parallel to each other and perpendicularly to the rails 3 of load carrier 4. At weight-transmitting devices 5 weight-measuring devices 6 with standard strain-gage sensors 7 are installed. Over weight-measuring devices 6 loading devices 8 (hydraulic jacks) are installed, which are connected with pipes in parallel to the pressure source that ensures their simultaneous action. After that onto loading devices 8 along rails 3 of load carrier 4 load-receiving devices 9 made in the shape of a set of beams with connection element are horizontally put on. Then by rails 3 of the approach lines both rail cars 1 are brought from opposite sides to load carrier 4 and stopped them at a distance that their wheelsets 2 should be located outside of load carrier 4. Then by means of clamps 10 of load-receiving devices 9 on both sides first wheels of wheelsets 2 are grappled and rigidly fixed at rails 3 of the approach lines from subsequent moving of cars 1. After that pressure in the hydraulic circuit of loading devices 8 is gradually changed, as a result of which the load force changes that is transmitted from loading devices 8 through weight-transmitting device 5 to load carrier 4 and at the same time to weight-measuring device 6 with standard strain-gage sensors 7. The load force is initially raised up to the maximum weighing level and then is diminished up to the minimum 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.

The VNKU-60 device has the following technical characteristics:

Largest weighing limit, LWL, kg	60,000
Smallest weighing limit, SWL, kg	400
Bound of absolute error of replication and weight measurement, kg	±31.5 (for sensors C_3)

±23.6 (for sensors C_4)
±18.9 (for sensors A_5M)

Climatic version according to GOST 15150-69
Load module UHL3, °C –20…+ 40
Control 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, no more than, W 53
Operating temperature range, °C –20…+ 40
Overall dimensions (LxBxH), mm 6584x1910x950
Total weight, no more than, kg 1750
Maximimum weight of single structural member, no more than, kg 70

The total quantity of the sensors installed in version 2 of VNKU-60 is half as many as that for version 1 and amounts to 18 units. A power bridge of three ZEMIC H8C beam strain-gage sensors with accuracy class: C_3, C_4, or A_5M with rated load of 5,000 kg is used for measuring tensile forces in the stretch/pinch mode. According to i. 1.2 of DSTU OIML R 60:2010 and recommendation [10; 11] the error of all 18 strain-gage sensors shall be considered in the aggregate if the operating characteristics of these sensors are referred to the envelope of introduced errors. Hence it follows that the bound of introduced error of the VNKU-60 device according to a sensor class is:

$$\Delta = \frac{5000\ kg}{3000} \cdot 1{,}05 \cdot 18 \approx \pm 31{,}5\ kg,$$

$$\Delta = \frac{5000\ kg}{4000} \cdot 1{,}05 \cdot 18 \approx \pm 23{,}6\ kg,$$

$$\Delta = \frac{5000\ kg}{5000} \cdot 1{,}05 \cdot 18 \approx \pm 18{,}9\ kg,$$

therefore according to the requirements of i.3.5 and i.3.7 [1], VNKU-60 can be used as an auxiliary verifier for verifying the platform railroad scales with calibrating interval of e=50 kg only during the operation with the bound of introduced error less than ±2e=100 kg.

To verify the very VNKU-60 device, 30 standard weights of M_1 class are used. In this case the bound of introduced error is:

$$\Delta = 0{,}1\ kg \cdot 30 = \pm 3\ kg,$$

that fully meets the requirements of i.3.7.2 [1].

Conclusions

The new design version of the VNKU-60 auxiliary verifier meets the requirements of Ukrainian technical regulations [9] which were developed on the basis of Directive 2009/23/EU on non-automatic weighing instruments and also the requirements of i.3.7 for verification standard devices [1] in the part of i.3.7.2 that concerns auxiliary verifiers. Existence of two different design versions of the VNKU-60 auxiliary verifier increases profitability of their wide application in practice of weight-free verification or calibration of large-load platform railroad scales in Ukraine. And in the absence of additional costs for a modernization of car complexes and mobility of the elaborated VNKU-60 device make it very attractive for application in weight-free verification in comparison with weight-verification cars.

References

1. DSTU EN 45501:2007 “Automatic weighing instruments. General technical requirements and test methods.” (EN 45501:1992, IDT).
2. GOST 29329-92 “Scales for static weighing. General technical requirements”.
3. GOST 8.453-82 “State uniformity measurement system. Scales for static weighing. Methods and means of checking”
4. DSTU OIML R 111-1:2008 “Weights of accuracy classes E_1,E_2,F_1,F_2, M_1, M_2, M_{2-3}, i M_3. Part 1. General technical requirements and test methods” (OIML R 111-1:2004, IDT).
5. Procedural instruction 2520-99 “Recommendation. State uniformity measurement system. Electromechanic heavy scales. Methods and means of checking” (GosStandart).
6. Boryak K. F., Vaganov O. I., Kolomiets L. V., Lopatin O. O., Tsimbalyuk A. G. Method of weightless calibration of platform scales. Utility model. u2015 070071 from 15.07.2015.
7. Boryak K. F., Kolomiets L. V., Lopatin O. O., Tsimbalyuk A. G. Device for weightless calibration of platform scales. Utility model. u2015 07465 from 24.07.2015.
8. Boryak K. F., Kolomiets L. V., Lopatin O. O., Tsimbalyuk A. G. Device for weightless calibration of platform scales. Utility model. u2015 070071 from 25.08.2015.
9. Technical regulations of non-automatic devices for weighing. Resolution of Cabinet of Ministers of Ukraine from 11.03.2009 No 190.
10. Erratum: OIML R 60(E) (Edition 2000) International recommendation. Metrological regulation for load cells.
11. DSTU OIML R 60:2010 “Loading sensors (weight). Metrological norms and test methods” (OIML R 60:2000, IDT).