



THE SYSTEMS OF AUTOMATIC WEIGHT CONTROL OF VEHICLES IN THE ROAD AND RAIL TRANSPORT IN POLAND

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ABSTRACT. Condition of roads in Poland, despite the on-going modernisation works is still unsatisfactory. One reason is the excessive wear caused by overloaded vehicles. This problem also applies to rail transport, although to a much lesser extent. One solution may be the system of automatic weight control of road and rail vehicles. The article describes the legal and organizational conditions of oversize vehicles inspection in Poland. Characterized current practices weighing road vehicles, based on measurements of static technology. The article includes the description of the existing applications of the automatic dynamic weighing technology, known as systems WIM (Weigh in Motion). Additionally, the weighing technology and construction of weighing stands in road and rail are characterized. The article ends with authors' conclusions indicating the direction and ways of improving the weighing control systems for vehicles.

Key words: road transport, vehicle weighing systems, automatic and dynamic weighing.

INTRODUCTION

The periodic analyses of technical condition of the road and rail infrastructure in Poland indicate the annually increasing maintenance needs. Despite allocating enormous financial means, which come mainly from the EU programmes it, has been unsuccessful to decrease the number of roads and railways needing repair. In the road transport road surface repairs of interventional character are continuous especially where the surface condition directly poses danger to road safety. Planned repairs of periodic character are carried out thereafter, which causes that the line of roads awaiting renovation gets longer and longer. A similar situation is present in the rail transport, though there the lack of finances for renovation and regular maintenance results in closure of a particular railway.

The main reason for the gradual deterioration of the road and rail infrastructure is its operational wear. In the road transport the dynamic increase of means of transport may be taken into account. The growth often exceeds the forecast values of traffic intensity for which a particular road was designed. The operational wear of roads and railways is predictable and directly proportional to the number of assisted means of transport. However, there is a factor which was not considered by designers while scheduling, according to the regulations, subsequent repair periods. It is the additional wear caused by the passage of overloaded means of transport with bigger weight than the permissible one or bigger than the allowed pressure on the axles. A number of such non-standard vehicles which move legally after obtaining an appropriate licence, or illegally without such a licence is very big both in the road and rail transport. This is due to those overloaded rail cars and road trailers that the transport infrastructure undergoes the relevant and abnormal wear in Poland.

The statistical data relating to the technical condition of roads in Poland are alarming: 25% of roads require the planned repair and 21% of roads require immediate repair. Research demonstrates that the exceeding of the permissible pressure on the axles brings about a hundred times bigger result of the road surface damage. For example, if the pressure on the axles of about 10% vehicles moving along the examined road were 145 kN instead of the allowed maximum 115 kN, which is in force for selected domestic roads and motorways, the road's life expectancy would be shortened by 25%.

The standard control of loaded means of transport is hampered by its nature. Vehicles are in motion and even random checking requires assistance of many employees from appropriate supervision services. Especially in the road transport the control of a hundred thousand heavy vehicles, which move along all kinds of road beginning with motorways and ending at communal roads, is very limited in practice. Such factors as enormous scattering of subjects offering road transport services, a significant participation of foreign cars, the multi-level management and ownership structure as well as the complicated division of responsibility among the state and local administration bodies do not simplify the task. Such impediments have not affected the rail transport, yet.

The system of automatic control of vehicles must be a solution to these problems. It would be best if the weighing process was carried out in motion without the introduction of restrictions in transport liquidity.

Certainly, a number of questions arises involving technological and economic conditions of such a system. These can be already answered. Moreover, there are outlets of automatic technical inspection of vehicles both in road and in rail transport in Poland. It is worthwhile analysing the examples and possible solutions to evaluate their usability for the future domestic system of vehicle control.

LEGAL REGULATIONS IN THE SCOPE OF VEHICLE TECHNICAL CONTROL

The regulations referring to the process of technical control of wheel and rail vehicles impose obligations on shipping agencies and they grant competences to the infrastructure managers and to a number of outward institutions to make them perform specific actions in this scope. Road and rail carriers are obliged to obey the appropriate regulations referring to the technical inspection of vehicles, the way of distribution and fastening of cargo as well as the organization of non-standard transport. Road and rail administrators should protect the infrastructure from excessive wear though, on one hand, they have restricted control competences and possibility of imposing administrative fines and, on the other hand, they regulate the market of non-standard shipment by granting appropriate permits. Depending on the range of roads the road administrators in Poland include: the General Directorate for National Roads and Motorways (Generalna Dyrekcja Dróg Krajowych i Autostrad - GDDKiA), voivodship governors, powiat and village administrators. The rail infrastructure administrator is the PKP Polish Railway Lines S.A. (PKP Polskie Linie Kolejowe S.A. - PKP PLK S.A.). In Poland security of the road and rail transport is provided by the Police, which is in charge of control of means of transport, cargo as well as drivers or engine drivers. In addition, the Inspection of Road Transport (Inspekcja Transportu Drogowego - ITD) has been established which deals only with supervision of road shipment.

In the road transport legal regulations refer to the so called non-standard vehicles, that is vehicles which exceed the permissible maximum measurements or weight. According to the Road Traffic Act a non-standard vehicle is a vehicle or a group of vehicles whose pressure on the axles with cargo or without it is bigger than the permissible ones envisaged for a given road in the regulations of the act on public roads, or, whose dimensions and weight with cargo or without it are bigger than the permissible ones, envisaged in the regulations on road traffic with exception of buses in the scope of the axle pressure. Polish regulations comply with the EU law in this aspect, especially with the Directive 96/53:

- 1) maximum permissible vehicle lengths:
 - motor vehicle or trailer - 12,00 m,

- articulated vehicle - 16,50 m,
- road train - 18,75 m;
- 2) maximum permissible vehicle widths:
 - all vehicles - 2,55 m,
 - superstructures of conditioned vehicles - 2,60 m.
 - maximum permissible vehicle height - 4,00 m.
- 3) maximum permissible vehicle weights:
 - road trans or articulated vehicles - 40 t,
 - articulated vehicles carrying 40-foot containers - 44 t.

The application of automatic measurement equipment in the road transport causes a number of legal controversies referring to supervisory powers of control bodies, legality of measurement equipment and precision of registered data and the possibility of sanctions on their basis. Most of all legal limitations refer to punishing offenders on the basis of the registered data by the WIM (Weight in Motion) measurement device. Currently, the Police, the Inspection of Road Transport (ITD) and other supervisory bodies can use equipment of this kind in the road traffic on condition that they are authorized. Then they are subject to the legal metrological control which includes validation of the type along with the original legalization and then the relegalizations. The lack of an appropriate legalization or an excessive measuring error for the WIM devices excludes their practical use in the road transport.

In the rail transport non-standard cargo is called special shipment, which means it may cause difficulties in rail carriage and, according to the administrator of the rail infrastructure, it requires special techno-movable conditions due to its:

- shape, dimensions or weight,
- method of loading, distribution and carriage protection,
- used means of transport,
- route of shipment.

The special shipment was defined in the Instructions of PKP PLK S.A., according to which they are among others:

- objects which exceed the determined loading gauge or which are loaded with this gauge's surpass,
- objects where one item weighs over 60 t,
- objects which cause that the load staying on the carriage axle or the current meter of the rail is bigger than the permissible one even at a section of the route,
- specialist rail vehicles e.g. cranes, rail and road machines,
- rail vehicles of exceeded rolling stock,
- objects that require a specialist carriage, equipment, protection or special organization of transport due to the position of the centre of gravity or other reasons related to the safety of carriage,
- objects which require shipment in the hollow floor ,
- rails, steel rods for concrete reinforcement and flexible metals of the length of over 36 m.

In the rail transport the law enforcement body which would be entitled to punish dishonest shipping agencies has not been appointed, yet. In case of failure of meeting conditions of safe carriage only the

units of the Rail Traffic Management and the Rail Traffic Administration Centre are authorized to halt the carriage.

SYSTEMS OF CONTROL IN THE ROAD TRANSPORT

At present the technical inspection of vehicles during shipment requires an appropriate stand equipped with a statistic measuring device making it possible to check such parameters as: total weight, pressure on the axles, length, width and height of a vehicle. Such stands are located by major roads and their construction is prepared to install mobile measurement equipment. Stands of such a type are equipped in stationary measuring devices very rarely. At the beginning of 2010 no more than ten stands located by Polish domestic roads and motorways were equipped with stationary scales for over 120 stands. Unfortunately, often those unsupervised roadside stands are devastated to such extent that they cannot play its function of control. Plans are being made of a considerable increase of control stands, especially on the newly built express roads and motorways.

Stationary scales are often concrete platforms and traps embedded in the ground so that the weighed vehicle is at the same level as the road. Mobile scales are sloping steel constructions or light mats laid out onto a flat surface of the road. A key role in the stationary and mobile scales belongs to piezoelectric and magnetoelastic detectors as well as dial extensometers. The measurement is a static one or a vehicle can move with the maximum speed of 5 km/h. The accuracy of the measurement depends on the applied metrological technology and is up to 0,1%. Due to the electric properties of scales it is possible to connect them to a computer or a printer. As a rule a measurement is conducted by two people, usually the ITD inspectors or the Police functionaries. In the present state of law representatives of the road administrator, e.g. municipal guard services are not entitled to stop cars, which limits their control possibilities.

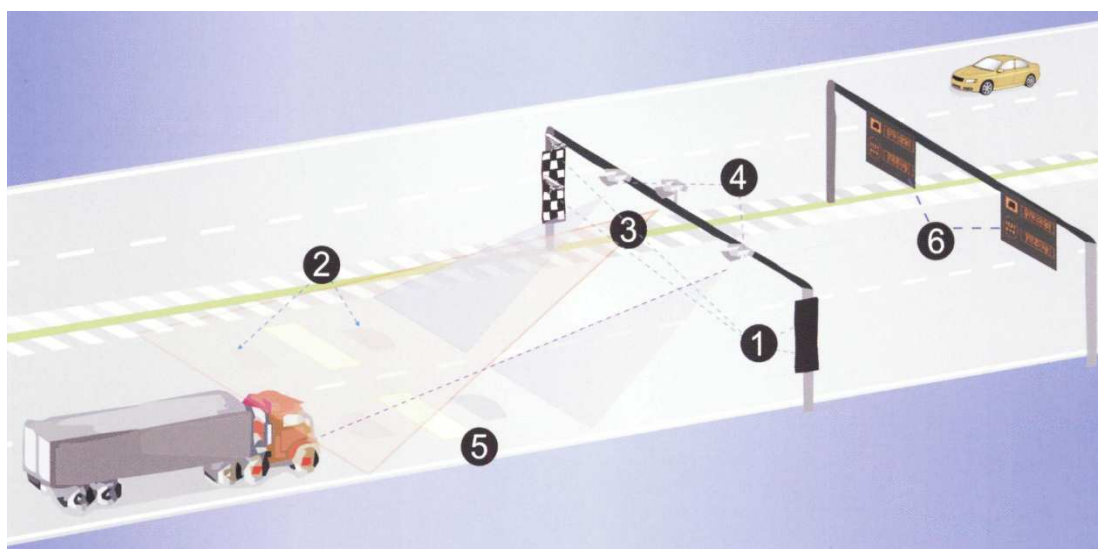
The system of control of vehicles in motion which requires the dynamic measurements is only at the initial stage of construction. At present there are only a few stands for weight preselection and the leader city is Wrocław which has 5 such stands. In order to measure the force of vehicle pressure on the road surface different systems of weighing platforms, piezoelectric or quartz detectors are applied. Platforms or detectors are installed on the road's lane and they enable to measure a vehicle's speed up to 140 km/h. It is significant since such a method of measurement does not hinder the flow of vehicles in the slightest degree. The information on pressure on the axles and the total weight is transferred to the management system. Nowadays it is impossible to execute fines on the basis of measurements conducted in this way because there is a big error involved. External conditions have a big influence on the measurement accuracy and they are: rain, low temperature, wind as well as a vehicle's velocity and acceleration. Producers claim that the scales based on modern quartz detectors exhibit the maximum measuring error at the level of 10% and in Poland the condition to authorize such vehicles is the maximum error at the level of 2% [Doupal E., 2010].

The lack of possibility of penalties execution on the basis of the dynamic measurement caused that scales of this type are used only for vehicle preselection. On the basis of the remote monitoring of the dynamic measurement records vehicles are selected for the specific measurements carried out on the static scales. As a rule, stands for static weighing are located at a distance of nearly a kilometre from the dynamic scales so that it should be possible to effectively stop the selected vehicle. Such a preselecting system works at the tollgates in Wrocław and it effectively protects municipal roads from overloaded vehicles.

The nowadays existing system of weight preselection can be easily extended by adding modules of external measurement of vehicles, that is their length and height. The accuracy of the dynamic measurements is much bigger. The extended preselection system for technical inspection of vehicles in motion comprises the following elements: (fig. 1):

- 1) camcoder for vehicle height and length measurement,

- 2) induction loops for connecting/disconnecting of weight detectors (depending on the applied technology)
- 3) pictorial camcoder,
- 4) camcoder for recognition of vehicle number plates ,
- 5) weight platform or detectors ,
- 6) information boards of changeable contents for drivers.



Source: Neurosoft promotional materials

Fig. 1. The preselection system of vehicles in motion

Rys. 1. System preselekcji pojazdów w ruchu

The passage of every vehicle through the preselective section is registered and then the data are recorded as the XML files. The files include readings from detectors as well as two photographs, from the measurement camcoder and the pictorial camcoder. These data enable to read the vehicle number plates, to determine the make, model and colour, its velocity, length and height as well as the vehicle's top inspection (along with its cargo) [Karp W., 2010]. The system is characterized by a considerable accuracy of readings, for instance, in good light conditions the module for recognition of vehicle number plates correctly recognizes over 95% vehicles. The processed data can be transmitted and presented on monitors of the control services in the real time and they are filed in archives. In this way, the established data base can undergo a statistical analysis in the scope of, among others: intensity and the average velocity of traffic depending on time and type of vehicle, the structure of transit and local motion with respect to time. As of today, data from several points of vehicle preselection are transmitted to the GDDKiA and the ITD servers.

Nowadays in Poland it is impossible to execute penalties automatically on the basis of the systems measuring in motion. There is a barrier of quite a big error of the measuring equipment in the scope of reading of pressures on the road surface. However, this error was accepted by legislation in the Czech Republic where the WIM systems will be a basis for imposing administrative penalties as early as 2010. In fact, the road administrators and the Police of the country fear that numerous appeals will be lodged by drivers, which will undermine reliability of measurements due to the weather conditions of the surface condition. Aware of the fact that accuracy of the measurement deteriorates dramatically while braking or accelerating drivers may deliberately affect the measurement quality. Therefore, there is an opportunity for the Government and the public opinion in Poland to watch effectiveness of the application of the new measuring equipment and execution of penalties at our neighbour's in the South in order to draw suitable conclusions. The undoubted virtues of the systems of automatic control of

vehicles in motion which are measurement continuity, great possibility of analysis of the collected data, reliability of the system, relatively low costs due to the elimination of personal costs, immense prevention significance must be adjusted to legislative restrictions.

THE SYSTEMS OF CONTROL IN THE RAIL TRANSPORT

Along with the increase of the number of rail stock owners, there is a bigger need for control of overload of such transport particularly of the contact pressure between the wheel and the rail. The current data collection on the line and axle overload and on the speed control of vehicles is to ensure safety of this kind of transport but also allows for detection of the above mentioned parameters. As a result, it allows obtaining a real picture of the infrastructure condition and the transport limitations involved.

Relatively recently the safety of rail carriage referred to the load of rails only as long as it helped to determine the pressure on the axle or the vehicle weight. At present it seems to be crucial to detect ovality in the wheels of rail vehicles with relation to the velocities which are used by rail carriers or they would like to move with.

The systems for identification of dynamic load in the rail transport have long been the object of interest and they indicate the need for collection of more and more reliable data in conditions which will restrict transport the least.

Initially, in the road transport there were only bridge structures where extensometers or light pipe detectors were used for measurement. They are mounted inside the bridge structure during its construction or they are installed outside [Chatterjee P. and others 2006, Karoumi R. and others 2005]. Examples of such a type of measuring equipment are rail scales made with the use of prefabricated concrete elements like a platform or a foundation tank (fig. 3). The weighing electronic engineering of rail static scales, dynamic scales and static-dynamic scales consists of extensometers inserted into special elastomer beds as well as control electronics which uses specialist weighing PC software.



Fig. 2. The platform scales (top left), in the foundation tank (top right) and in the rail beams (bottom)
Rys. 2. Wagi kolejowe pomostowe (u góry z lewej), w wannie fundamentowej (u góry z prawej) i w podkładach kolejowych (u dołu)

The latest technological solution in the scope of weight control of rail carriages is scales which use concrete ground beams with embedded extensometers.

The scales do not require foundation since the weighing beams are positioned directly on the ground of stabilized breakstone. Moreover, as the producer claims, "a rail in the control zone must be isolated from the rails at the entering sections, which causes elimination of the transit velocity restriction". Due to this solution it is possible to control pressure on the axles of rail vehicles and to conduct inspection on the wheels of rail vehicles at the speed of up to 240 km/h (fig. 2).

Nowadays complex solutions are offered on the market in the scope of automatic weighing and identification of rail vehicles of the RAIL WIM (Rail Weight in Motion) type. For Polish lines the equipment of the DSAT (detection of emergency of the rail rolling stock) type is used. Such devices allow for:

- assessment of the pressure exerted by rail vehicles,
- detection of overheated, blocked brakes of rail vehicles,
- detection of overheated axle bearings of rail vehicles,
- detection of deformities of wheel raceway of rail vehicles.

Consequently, the application of the DSAT equipment plays its role in the safe realization of carriage services, that is, in reduction of risks of accidents, reduction of costs connected with the rolling stock's maintenance and in the extension of the lifespan of the infrastructure.

The temperature measurements are realized intangibly with the use of detectors working in the infrared band. Measurements of pressure and overload qualities are performed by light pipe detectors, which considerably allow avoiding the influence of electromagnetic interferences on the measurement value. The information obtained in this way is automatically processed by the electronic systems located in the by-rail compartment and transmitted to the operator stands of the PKP PLK S.A. which monitor rail vehicle movements, that is to the traffic engineering and technical services. Regularly new equipment of this type is installed on the main rail lines in Poland, on average twice a year in each region of particular rail agencies.

CONCLUSIONS

One of the most important objectives of the vehicle weight control systems is the elimination of the excessive damage of infrastructure by overloaded vehicles, which move along public roads and railways with exceeded permissible total weight or with big load pressure on the axles. The number of the road and rail infrastructure users is still increasing. The means of transport unsuitable for the carried shipment and in bad technical condition pose a risk not only for the state of the rail infrastructure but also for other users.

The WIM automatic systems for vehicle weighing seem to be a very good tool in the hands of the administrators of the transport infrastructure and control institutions. The previous experience is favourable in this respect. In the road transport, a good example is the system of automatic dynamic scales installed mainly on the main access roads to the city centre of Wrocław. In the rail transport, there are efficient systems of automatic vehicle weighing and control as well as the DSAT system for emergency detection of the rail rolling stock. Unfortunately, the systems displace the hitherto used systems of stationary or mobile static scales. Moreover, there are over thousand different kinds of weight control systems used in Poland and frequently they are analogue and require different kinds of interfaces which enable to interact with modern digital systems. These systems, mainly static ones, require continuous technical supervision along with authorization of scales, technical inspection and service repairs. These necessary activities are expensive and cause temporary disconnection of particular equipment and systems.

On the basis of the conducted analysis of the existing systems of weight control in road and rail transport in Poland a number of conclusions of strategic character can be formulated:

- 1) at present the vehicle weighing appliances have their limitations in the scope of measurement accuracy, therefore they can be used for vehicle preselection,
- 2) the improved WIM systems of the approved level of measurement should replace the conventional systems based on static measurement,
- 3) investment in new equipment and systems of vehicle weight control, though considerable, is profitable when compared with the costs of reconstruction of the transport infrastructure destroyed by overloaded vehicles,
- 4) additional advantage connected with replacement of the existing systems is the lack of increasing maintenance costs and adjustment to the requirements of the present digital systems,
- 5) the monitoring and control systems should be of intermodal character, that is, rail and road systems should interact and a common data base referring to overloaded vehicles should be accessible for all involved institutions and services in the real time
- 6) it is necessary to implement a number of changes of legislative character, especially to include statutory provisions which will enable to execute penalties on carriers by using the data bases from the systems of automatic weight control of vehicles in motion.

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SYSTEMY AUTOMATYCZNEJ KONTROLI WAGOWEJ POJAZDÓW W TRANSPORCIE DROGOWYM I KOLEJOWYM W POLSCE

STRESZCZENIE. Stan dróg w Polsce pomimo trwających prac remontowych jest w dalszym ciągu niezadawalający. Jedną z przyczyn jest nadmierne zużycie nawierzchni spowodowane przeciążonymi pojazdami. Problem ten dotyczy także transportu kolejowego, choć w dużo mniejszym zakresie. Jednym z rozwiązań systemowych może być automatyczna kontrola pojazdów w transporcie drogowym i kolejowym. Artykuł podaje uwarunkowania prawne i organizacyjne kontroli nienormatywnych pojazdów w Polsce. Scharakteryzowano obecnie stosowane praktyki ważenia pojazdów drogowych, oparte na technologiach pomiarów statycznych. Opisano istniejące możliwości zastosowania technologii automatycznego ważenia dynamicznego, określane, jako systemy WiM (Weigh in Motion). Scharakteryzowano technologie pomiaru i stanowiska pomiarowe w transporcie drogowym i kolejowym. Artykuł kończą autorskie wnioski wskazujące kierunki i sposoby udoskonalania systemów kontroli wagowej pojazdów.

Słowa kluczowe: transport drogowy, systemy ważenia pojazdów, ważenie dynamiczne i statyczne

DER AUTOMATISCHEN GEWICHTSKONTROLLE DER FAHRZEUGE IN DEN STRASSEN- UND SCHIENENVERKEHR IN POLEN

ZUSAMMENFASSUNG. Der Zustand der Straßen in Polen, trotz der laufenden Modernisierungsarbeiten, ist noch unbefriedigend. Die übermäßige Abnutzung der Oberfläche von überladenen Fahrzeugen ist einen von Gründen dafür. Dieses Problem betrifft auch den Schienenverkehr, aber in wesentlich geringerem Umfang. Eine Lösung kann das System der automatischen Gewichtskontrolle von Straßen- und Schienenfahrzeuge sein. Der Artikel beschreibt die rechtlichen und organisatorischen Bedingungen für die Inspektion von den übergroßen Fahrzeugen in Polen. Die derzeitigen Praktiken der Wiegen von Straßenfahrzeugen, die auf die Technologien der statischen Messungen basieren, wurden beschrieben. Der Artikel enthält die Beschreibung der vorhandenen Anwendungen der automatischen dynamische Wiegetechnik, die als Systeme WIM (Weigh in Motion) bekannt sind. Zusätzlich, wurden die Messtechnik und Wiegenstelle in Straße- und Schienentransport gekennzeichnet. Der Artikel endet mit Schlussfolgerungen von Autoren über die Richtungen und Methoden zur Verbesserung der Kontrollsysteme zum Wiegen der Fahrzeuge.

Codewörter: Straßenverkehr, Wiegesysteme von Fahrzeuge, dynamische und statische Wägung.

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