SAFETY OF RAIL TRANSPORT IN THE ASPECT OF THE PROCESS OF PLACING IN SERVICE RAILWAY VEHICLES

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Abstract

Authorizing the placing in service of a rail vehicle, which is called in Polish "Regulations permitting a vehicle type to operation", is meant as a procedure carried out by appropriate authorities in order to hand over a rail vehicle to be operated in accordance with its purpose. A condition for permitting vehicle types to be operated is to obtain a certificate of placing in service for the first vehicle of a given type. One of the elements of these tests are line tests, i.e. tests realized along railway lines, which are aimed, among other things, at evaluating dynamic properties of a traction vehicle. The tests are realized on tracks of QN1, QN2 and QN3 class, according to the EN 14363 standard, where: QN1 - track of a very good maintenance condition, QN2 - track of a good maintenance condition, QN3 - track of a bad maintenance condition. However, it must be indicated that there exist in Poland also tracks of a very bad maintenance condition, which are not taken into account during the tests. A railway event being a result of operating a vehicle on tracks of a bad maintenance condition will be discussed as an example.

Keywords: Rail vehicles, authorization for placing in service, safety of railway transport

1. INTRODUCTION

Rail transport in the European Community plays an important role in the process of transporting both passengers as well as freights. This can be proved, among other things, by numerous decisions made by the European Parliament [1] as well as reports being interpretation of the policy of the balanced development of the EC countries, including the transport policy [2], [3]. Assumptions related to development of transport forecast that 30 % of the freights transported by means of the road transport over a distance longer than 300 km should be transferred to other transport facilities till 2030, e.g. rail vehicles or ships, whereas amount of the transported freights in this way should reach up to 50 % till 2050. Other assumptions are developing (almost three times) the existing system of high-speed railway and finishing construction of the European high-speed railway system until 2050 [11]. Development of the railway system is connected with introduction of new solutions, products, and services, which will improve the transportation and operation system, keeping at the same time its safety level [12,13]. Each subsystem of the railway system should be subjected to appropriate tests prior to placing it in service [2]. In the case of railway vehicles, their tests can be divided into these realized at the stage of designing, building and manufacturing a vehicle, and those carried out at the stage when authorizing the placing in service is acquired. Considerations presented in the paper will focus on the stage of authorizing the placing in service of railway vehicles in Poland. Procedures pertaining to tests of rail vehicles with regard to authorizing the placing in service are specified in documents of a formal-legal character. The documents include directives, decisions, laws and orders, which are published by the European Commission and by state legislative bodies. Documents such as, European standards, national standards, UIC cards (Union International of Railways) and Technical Specifications on Interoperability (TSI) define procedures of testing railway vehicles [4]. The body that oversees the Community rail market is the European Railway Agency - ERA (Agence Ferroviaire Européenne - in French). It was appointed in accordance with order No. 881/2004 of the European Parliament and the Council dated 29 April 2004 [5]. The essential function of activities of this institution results from a need of existence of a European regulator of the railway market with regard to the safety of the rail transport, observing the passenger rights, ensuring interoperability of the railway system, as well as with regard to technical specifications on interoperability. Each member country has a so-called body for safety affairs; in the case of Poland it is the Office of Rail Transport [6]. Despite the existence of European and national legal regulations regarding the implementation of the admission process for rail vehicles, dangerous rail accidents and incidents occur. Analysis of these events shows that the procedure of certification tests on the railway line contains logical gaps and inconsistencies that are one of the causes of subsequent accidents [13]. The aim of the article is to present these procedural shortcomings and to show an example of a real railway event and propose some changes in the approval testing process.

2. FORMAL-LEGAL FACTORS PERTAINING TO THE PROCESS OF PLACING IN SERVICE OF A RAIL VEHICLE

The process of placing in service is similar to the procedures for the official certification of automotive vehicles and it ends with the issuance of a formal document authorizing the vehicle to be operated. Depending on type of the document issued, a particular kind of operation of a given vehicle is entitled. It is obviously connected with the procedure for authorizing placing in service. The basic legal act regarding railway transport is the Act on railway transport dated 28 March 2003 [6] as well as related executive acts (ordinances) specifying the procedure for authorizing the placing in service of a type of railway vehicle, type of building and type of railway device. A next amendment to the Railway Transport Act dated 16 September 2011 was aimed at implementing the provisions of Directive No. 2008/57/ EC of the European Parliament and of the Council on the interoperability of the rail system in the Community dated 17 June 2008, as well as Directive No. 2008/110/EC dated 16 December 2008 amending Directive No. 2004/49/EC on the safety of railways within the Community (Railway Safety Directive). Changes introduced in the scope of implementation of the Directive provisions referred both to the process of placing in service itself, i.e. in the scope of permits for structural and functional subsystems, rules of mutual honoring of the permits already issued for structural and functional subsystems, as well as acceptance of assessment procedures of compatibility and certification procedures for interoperability components. The body issuing documents authorizing placement in service of railway vehicles in Poland is the President of the Office of Rail Transport (ORT). These documents may have one of the following forms:

- certificates of authorization for placing in service of a type of a railway vehicle,
- authorization for placing in service of a railway vehicle.

Verification of the fact that a vehicle meets conditions specified in the relevant regulations [4], [6] is carried out by an authorized body that participates in the process of authorizing for placing in service. The authorized certification body, after performing the necessary tests, is obliged to issue a TSI-compliant vehicle certificate. Provided all activities connected with the provisions included in [6] in the scope of placing in service are met, and all subsystems of a railway vehicle have been authorized for placing in service, then the President of the ORT should issue a certificate of authorization for placing in service of the first vehicle of a given type. As aforementioned, before obtaining a certificate of authorization for placing in service, a vehicle of a given type is subjected to technical tests, which are carried out by an authorized organizational unit. One of the elements of these tests are line tests, i.e. tests carried out on railway lines, aimed, among other things, at:

- evaluating dynamic properties of the rail vehicle,
- checking strength of the main elements, especially fatigue strength of the bogie frames.

It should be mentioned that the provisions of the order [4] apply both to vehicles running on infrastructure with a track width of 1,435 mm or other, as well as to vehicles running on a separated infrastructure, such as railway lines for commuter railways, railway sidings, vintage and historical vehicle lines or subway vehicles.

3. TECHNICAL TESTS IN THE PROCESS OF CERTIFYING AUTORIZATION FOR PLACING IN SERVICE

The scope of technical tests to be performed within the procedure of authorizing for the placing in service is specified in the order [7]. It should be mentioned that the said order is another version of a similar order issued 2005, and the changes introduced are the result of updating EU directives concerning this matter. The authorized testing unit performs the tests listed in the order [7] and then prepares a respective report, which is the basis for issuing the certificate of authorizing for placing in service of a vehicle. One of the elements of such test are line tests of the vehicle, i.e. tests performed on railway lines, aimed, among other things, at:

1) Evaluation of dynamic properties of a railway vehicle, in particular in the scope of:

- determining the Y/Q safety factor related to derailment under quasi-static and dynamic conditions,
- determining forces acting between the wheel and the rail,
- smoothness of running;

2) Checking the strength of the main elements, including:
- strength of the box and the mountings of devices,
- fatigue strength of bogie frames,
- characteristics of colliding-rod devices and their fatigue tests,
- resistance to impact and pressure changes.

These tests are performed on tracks of QN1, QN2 and QN3 class, accepting in accordance with the EN 14363 standard [8] the following percentage share of the above classes of tracks:
- 50 %: share of track of class QN1
- 40 %: share of track of class QN2
- 10 %: share of track of class QN3

where:

QN1 - track of a very good condition of maintenance
QN2 - track of a good condition of maintenance
QN3 - track of a bad condition of maintenance

The above provision should be understood as follows: if the tested vehicle, rode for instance 100 km, it did not ride more than 10 km along QN3 class tracks (tracks of poor maintenance condition), whereas it rode 90 km along QN1 and QN2 class tracks, thus keeping the specified proportions.

However, it should be emphasized that there also exist in Poland tracks *of very poor maintenance condition*, which is not taken into account during the test, i.e. **the vehicle is not tested on such tracks assuming that the tested vehicle will not be operated on such tracks or will be operated only to a limited extent**. Meanwhile, the operational practice shows that the share of tracks of poor and very poor maintenance condition may exceed 50 % while operating rail vehicles. Obviously, in such cases, the limiting values of vertical and horizontal accelerations, and thus the forces affecting individual vehicle components, with the bogie frame included, are considerably exceeded, what results in reduction of the assumed unlimited durability of the mechanical structure. The assumed 30-year service life (vehicle lifecycle) will not be achieved then. In addition, in the case of faults in the technology of manufacturing the vehicle or during its assembly, initiation of a cracking process in the nodes of the structure, particularly vulnerable to such processes, may occur sooner than it is expected according to the standard.

If the carrier and the infrastructure manager does not possess such knowledge, during operation of a vehicle some events may occur that threaten the safety of the railway system. Moreover, if the design engineer had information from the carrier regarding the track classes along which the ordered vehicle is to be operated, and the share of these tracks in its overall operation, and at the same time the carrier had relevant information from the infrastructure manager regarding the same matter, he could assume at the design stage a higher standard safety factors, what would allow the assumed technical parameters of the vehicle structure to be achieved. In the next section we will present an exemplary railway event, whose final effect resulted from the aforementioned elements.

4. EXEMPLARY RAILWAY EVENT

On 22nd December 2015, in the afternoon, along a route Opole Zachodnie - Nysa, in the town of Komprachcice, a passenger train, operated by a vehicle of SA134 type (**Figure 1**), after passing the railway crossing at km 6.171, where the speed limit was 20 km/h, accelerated to a speed of 25.5 km/h and derailed on the left curve of the track with the second axis of the middle bogie on the right side towards the direction of riding.

Figure 1 Passenger train [own study]

As it results from the description of the event, the train speed was small and its value resulted from the condition of the track infrastructure of this route. There were no casualties. As usually in such cases, the State Commission of Investigations of Railway Accidents set about working and after few months of investigations, having a support of additional research performed by the Railway Research Institute, the commission published a respective Report [9]. The following was stated in the report:

"At the derailment spot, the following was discovered with respect to the railway vehicle SA134:

− a crack of the bogie frame, starting at the corner of the axle guard towards the upper plate of the bogie frame on both sides of the wall of the box structure − a fresh crack,

− traces of rust at the spot of joining the lateral plane of the vertical liner with the horizontal plane of the axle guard of the box corner − old cracks,"

whereas, regarding the causes of the occurrence of the crack, the Report reads:

"... the commission states that the following factors caused formation of the crack:

a) fatigue strength of the frame structure (without manufacturing defects, manufactured in accordance with the construction documentation employing a proper production technology),

b) production technology (especially welding technology),

c) condition of the railway infrastructure, along which the vehicle rode (especially vertical inequalities of rail tracks and twist of the track) as well as mutual interaction between particular infrastructure elements."

The authors of the paper focused their attention on the cause c). At this point, attention should be paid to the inconsistency between the conditions determining how the tests should be conducted at the stage of the official certification (50 % of rides along tracks of the QN1 class, 40 % of rides along tracks of the QN2 class, 10 % of the rides along tracks of the QN3 class) and the real conditions while operating the vehicle later, when there does not exist any other monitoring regarding condition of the tracks, along which the transports are realized. Under extreme conditions, the rides may be even realized only on tracks of poor maintenance condition and very poor maintenance condition. As indicated by analyses of the routes along which the passenger vehicle was operated, in the considered case operation of the SA134 vehicle took place along the following routes: Opole - Kluczbork, Opole - Kędzierzyn-Koźle, Opole - Nysa, Nysa - Brzeg and Nysa - Kędzierzyn-Koźle. The track of these routes has been defined in the report [9] as a track of poor and very poor maintenance condition. Measurements of the condition of the track, performed by the Diagnostic Laboratory of the Railway Lines Division for routes along which this type of vehicle was running, are listed in **Table 1.**

Table 1 List of defects of the track in the case of routes, along which the vehicle type SA 134 wasoperated - original version issued by the laboratory [9]

List of defects on the basis of analysis of tabular prints of measurements performed by measuring vehicles, delivered with the document IZDKa-511-23/2016 dated 3 March 2016, by PKP PLA S.A. Division of Railway Lines in Opole (it regards routes, on which railway the vehicle SA134-011 run as a train)					
No. of Railway Route	**Total Length of the Tracks Measured (km)**	**Number of Defects in "C" Class - after Measurements Realized by Means of a Trolley EM120**	**Number of Defects Exceeding the Permissible Limit "C"- 0≥25 % - Denoted with "*"**	**Number of Defects Denoted with "@" - Defect Cannot Be Assigned to any Category of Speed Intervals**	**Number of Defects Denoted with "#" - Exceeding the Limit Values - Measurement by Means of Electronic TEC 1435 Track Gauge**
136	t1 37.602 - t2 37.801	608 642	256 270	75 125	–
137 Katowice - Legnica	t1 50.979 - t2 46.000	880 1552	528 1109	43 86	–
	t1 61.143 - t2 68.000	–	–	–	1420 2239
287	48.400	–	–	–	1604
288	47.555	–	–	–	2037
293	25.210	–	–	–	834
297	7.890	–	–	–	186
301	19.810	–	–	–	404

The symbols of the defects have the following meaning:

- C - defect below the permissible limit,
- C^* - defect exceeding the permissible limit by 25 %,
- @ - defect that cannot be assigned to any category of speed intervals,
- # - defect exceeding the permissible limit values (measurement by means of electronic TEC track gauge).

Besides, test rides along the routes listed in **Table 1** were carried out, connected with measurements of vertical accelerations at selected points of the bogie frame, being a result of interactions with the track, according to the standard [10]. Studies have shown that recorded accelerations were exceeded by up to 30 % on these routes (analyzed according to PN-EN 14363 standard [8,12,13]). Routes having these tracks were operated mainly by vehicles of the SA134 type, whereas at the stage of tests pertaining to placing in service - official certification, share of these tracks in the tests was at the level not exceeding 10 %.

5. CONCLUSIONS

The presented considerations proved that conditions, under which the tests pertaining to placing in service are realized, in specific cases may considerably differ from conditions, under which given type of a vehicle is operated. The conditions, and especially condition of the infrastructure may significantly influence the durability - the life, of a rail vehicle and its subunits, in this case frame of the bogie of the rail vehicle.

A statement that condition of any infrastructure, not only the rail infrastructure, as well as operation conditions have influence on life of any device, a vehicle in this case, is out of question; it is most certain. However, in the case of a specific rail vehicle and a specific operation situation, the problem of qualitative and quantitative assessment of a particular event requires some study and analyses.

With regard to the condition of the infrastructure - condition of the tracks, on which the vehicle type SA134 was operated, it should be stated that the condition accelerated a phenomenon of cracking of the bogie frame, thus it contributed to shortening the life of the frame and decreasing its durability, what resulted in the derailment of the vehicle.

Assessing regulations related to the tests pertaining to placing in service of rail vehicles, some amendments should be postulated for, which would take into account condition of the track infrastructure to be used in the future operation of the tested vehicle, or would order to exclude tracts, which are evaluated as very bad. These actions would improve safety of realizing rail transportations.

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