

Research Capabilities and Significance of a Test Track for Railways

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Summary

The article presents the reason behind the creation of a testing plot, its tasks and research capabilities as well as the significance of the test track for railways. The track system and structures are described in terms of testing.

Keywords: research, railways, infrastructure

1. Introduction

Until now (2019), the Test Track near Żmigród has been used for 23 years. On 12 September 1996, the facility was launched and, at the same time, marked the biggest investment of the Scientific and Technical Center of Railway (currently the Railway Research Institute). Another crucial event in the history of railways was when the facility was put into service. This plant is part of the Railway Research Institute, which manages it and researches in accordance with specific programs and research plans. The track is subject to various experiments related to the implementation of innovative solutions in railways.

2. Reasons for facility creation

The railway industry is a large enterprise composed of many related and cooperating branches. In the 1970s and 1980s, PKP [Polish State Railways] represented the main branch of transportation of people and goods. However, the quality of these services substantially deviated from Western European standards. There was a need to make quality-related changes in transport in the form of new technical and technological solutions, and to improve the quality of services rendered. The adoption of new, prototype solutions should be preceded by long-lasting and very rigorous research and tests. This is related to the nature of rail traffic. Railway devices are very important structures whose reliability and proper operation provide safety to the entire railway transport system. The basis for assessing the usefulness of new solutions are labora-

tory tests and then field testing. The field tests are tests in real conditions and performing them on active railway routes led to the extension of research and development works, as well as posing a threat to research teams and railway users.

Construction of the Test Track was entered into the Central Research and Development Program no. 9.3 under the name: "Transport service of national economy and society" which was supposed to be completed in the years 1986–1990. The program assumed research and development works in the following fields of railway:

- rolling stock,
- superstructure,
- electric traction equipment,
- automatics,
- telecommunications.

The main directions of this program derived from the assessment of the situation in rail transport. The research and development works were aimed at:

- 1) increasing durability of the railroad superstructure,
- 2) improving reliability of the electric traction power supply,
- 3) improving the technical condition of the rolling stock,
- 4) building modern freight cars along with their elements,
- 5) building modern rail vehicles and their equipment,
- 6) automating freight car kicking processes,
- 7) streamlining railway traffic,
- 8) modernizing and equipping general-cargo tracks at stations.

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Achievement of the aforesaid goals in the form of specific technical solutions and ready goods requires the implementation of thorough research and measurements in real operating conditions. The subjects covered by the goals from 1) to 5) must be completed in strictly defined conditions and research programs, and for this purpose the best solution is a test track which allows increased complexity of research, modeling and comparative tests, as well as being likely to result in substantially shorter research time. On 24 September 1986, the construction of the so-called Small Circle as the preemptive goal no. 21.102 was included in CPBR no. 9.3 [1–4, 8].

3. PKP testing plot plan

According to the plan, the railway testing plot should consist of two circles and a delivery and receipt station (Fig. 1). The so-called Large Circle in question was intended to test rail vehicles at high speeds. The intention was to reach speeds from 200 km/h to 300 km/h. Additionally, for research purposes involving speeds of more than 200 km/h, railroad turnouts were to be mounted.

The Small Circle is a rail structure primarily intended for surface tests, railway traffic control, telecommunications devices and other infrastructure used in railways. It was planned to test the rolling stock with a maximum speed of 120 km/h.

The delivery and receipt station is represented by a set of tracks on which rolling stock stops, tracks with equipment required for minor renovation works and preparatory works for rolling stock tests. Interestingly, test stands in the form of a crash stand and

the so-called reversed curves, a statistical survey hall and power supply from other voltage systems were planned as well [1–4, 8–9].

4. Technical specification of the existing facility

The curvilinear enclosed shape of the Test Circle, 7725 m long, is made of 25 rail sections, 300 m long, and a rail turnout section, 225 m long. The superstructure is equipped with UIC 60 rails partly on various concrete sleepers and wooden sleepers – softwood and hardwood. Based on the well-selected location of various kinds of sleepers and diverse types of fastening points, track sections differing in terms of structure and location on the plan were prepared (Fig. 2). This is of paramount importance in the process of conducting various types of surface tests.

The roadbed of the experimental loop track is formed by an embankment composed of permeable ground (sand, gravel) and secured with a protective layer from the top (key aggregated-based filtering layer and impenetrable layer based on thickened stone mix), and secured with a layer which separates from the subsoil surface from the bottom (gravel and all-in aggregate and stone mix). In addition, a few experimental sections were built, where the protective layer was based on key aggregate from Czarny Bór, old sub-crust from Wrocław Główny, medium sand, siftings and cement stabilization. The principal dehydration of the roadbed is represented by side and drainage ditches. The Experimental Circle is a non-contact track. It is composed of straight sections, 1313.9 m and

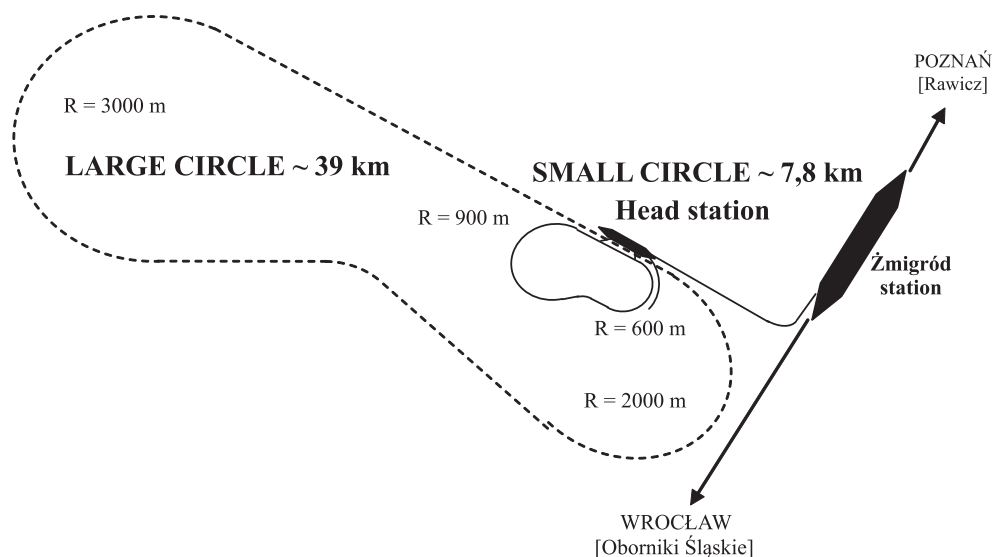
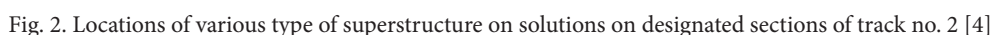


Fig. 1. PKP Testing Plot sketch as per the concept from 1986 [4]



In the longitudinal profile, the experimental loop consists of horizontal sections and inclined sections (1‰ and 2‰). There are rail turnouts no. 20 and 21. The facility is also equipped with head station tracks, which include track no. 1, 973 m long, track no. 3 and 3a, 852 m long, track no. 5, 352 m long, track no. 7, 224 m long, refuge siding no. 1c with an inspection pit, 66m long, steeply graded track no. 8a located at the curve with a radius of 605m, its useful length is 1000m, and tracks being part of the reversing triangle, track no. 10 in the shape of a curve with a radius of 150m, steeply graded track no. 8 and and access track no. 1a. The entire railway system is showed in Figure 3. The whole facility involves 12 rail turnouts. All of them are connected to PKP Żmigród station via the access tracks – track no. 101 and no. 1a, positioned in the closed part of railway line 317 Żmigród – Wąsosz (Fig. 4). The contact system is supplied with the voltage of 3.3kV-, the input power of the traction substation is 7.5 MW [1–4, 7–9].

In order to perform tests of the rolling stock, consisting of forcing specific longitudinal dynamics conditions of the measuring train set with a view to checking the susceptibility of the specific facility to potential derailling with the impact of strong longitudinal forces, track no. 4, the so-called reversed S curves, was built. This track branches off from track no. 2 through rail turnout S 60 – 300-1:9 near km 0.00 and goes along it in the area of the curve with a radius of 600 m from its internal side. The usable length of the track is 415 m. There is a straight track insert of 6 m between the reversed curves. The measuring train set consists of pushing locomotives, separating cars, the car in question and braking cars controlled with a separate air system (Fig. 5).

The special configuration of the experimental loop, and particularly three existing curves with radii of 600 m, 800 m and 900 m, in combination with an over one-kilometer straight section allow vehicles to be tested in terms of their dynamic performance. The speed of 160 km/h, permissible in this section, allows

traffic studies of the braking systems at this speed to be conducted. The train set, consisting of the locomotive, measuring car and properly loaded car in ques-

tion, accelerates to reach the specific speed and the car in question disconnects automatically – sudden braking is triggered (Fig. 6). The locomotive with a mea-

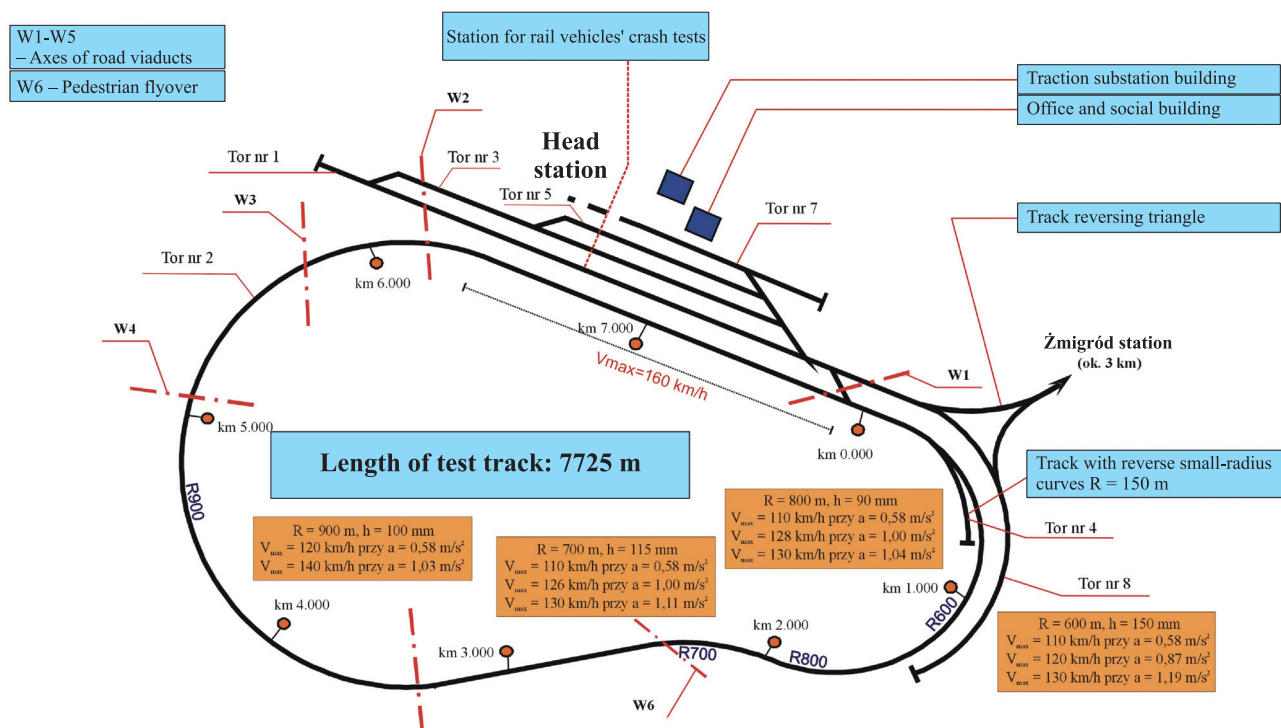


Fig. 3. Track system diagram [3]

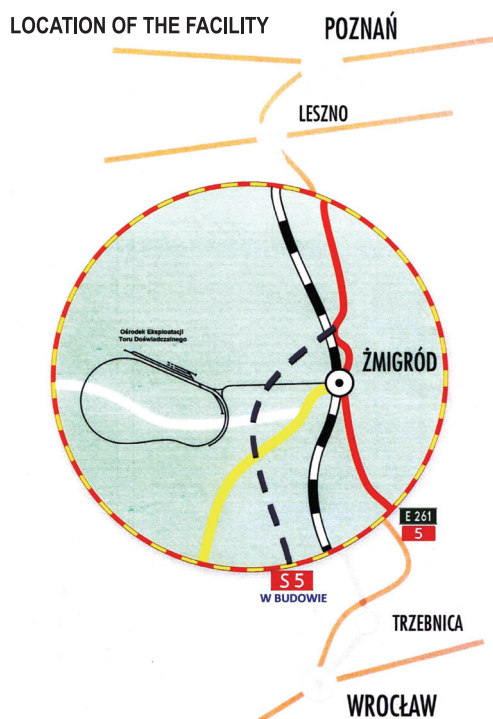


Fig. 4. Location of the test track [own elaboration]



Fig. 5. Measuring train set for testing on reversed curves [own elaboration]

suring car leaves safely. When the car in question stops, other carriages leave and link, and after checking the parameters it is possible to continue testing.

Testing the braking system with detachment can be performed on an active route but this entails mutual interference, the testing time is strictly defined, there must be detailed regulations and crucial spots must be covered by PKP PLK employees. Temporary closures of the route for the time of testing are relatively short and therefore the testing time prolongs substantially. The Small Circle is a convenient place prepared for such testing. The circle is equipped with overhead cranes and various kinds of ballast used to load cars jointly with the tank refueling stand.

On track no. 2, at 6.5 km, there is a separate track, around which acoustic neutrality is maintained and which is known for higher dynamic parameters and track geometry quality, that is used to test noise in accordance with requirements of the Technical Specification of Interoperability. In this section, noise generated by passing vehicles (both at a fixed speed and during startup) is measured.



Fig. 6. Measuring train set for testing the braking system of the tank car [own elaboration]

In view of the total separation from the PKP contact system and the possibility of total separation from the power network, for the purposes of testing interference generated by passing vehicles in railway circuits (Fig. 7), a special measuring stand was also created by track no. 2 [1–4, 6, 8].

6. Experimental tests of rail vehicle crashes and international projects

Among the most spectacular tests performed on the track are rail vehicle crash tests on a natural scale (Fig. 8). The first international tests of this sort were held in 1990 on a specially prepared stand located in the head station. Their purpose was to verify a new idea for constructing a cab based on the principle of gradual controlled crushing of its structural elements, yet this process should be accompanied by the maximum absorption of energy, as well as checking and assessment of the mathematical model for crushing the cab in order to use this model for future calculations. The participation of competent and experienced CNTK staff (at present, the Railway Research Institute) in this experiment and the availability of a suitable place for high-energy crash tests and elaborated measuring methods resulted in participation in numerous projects of this type, for example: Safetram – “safe” tram, Safetrain – “safe” train. Services of this sort were also used by Polish and foreign rail vehicle manufacturers.

Thanks to its features, the Test Track Center is also a perfect railway ground for various kinds of domestic and foreign projects in railways and related branches. The focus on all railway features available on the railway line, as well as non-standard actions which may

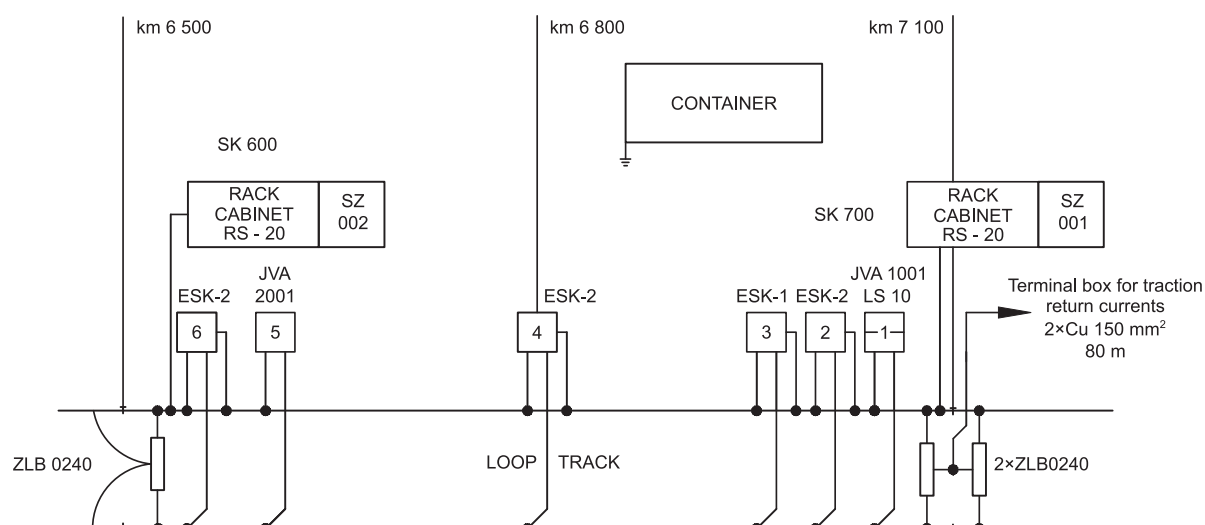


Fig. 7. Interference impact measuring stand diagram [own elaboration]



Fig. 8. Destructive tests on the Test Track [own elaboration]

be repeated many times and controlled without railway traffic interference, allowed the Test Circle to be used for such projects as:

- ProtectRail – potential threats and suggested IT solutions for improvement of safety in railways,
- Monit – testing rolling stock dynamic performance with the adoption of various kinds of interference [4].

7. Testing railway infrastructure equipment

The test track is primarily used to perform tests of the rolling stock, but the intended use of the testing plot allows tests of prototype structural solutions of railway infrastructure equipment to be performed. A prototype spring device for tightening the contact system (overhead cables) was mounted and tested (Fig. 9a). The tests and measurements were used to elaborate new and better technical solutions for this device and also allowed use on the contact system. A specially prepared test plan and the high frequency of rolling stock traveling through the measuring

points allowed a prototype hydraulic seal to be installed in the rail turnout (Fig. 9b). This device was tested throughout the year in various weather conditions. The installation of untested elements on railway routes, especially ones responsible for railway traffic safety, entails a risk of unpredictable emergencies. On the Test Track, such risk applies to research works which are aimed at specifying certain boundary conditions and safety limits. It is also necessary to emphasize that, after over twenty years of operation, the facility which was supposed to be dedicated to surface testing now hosts a 300-m testing section with a rail bed stabilized with a resin.

8. Significance of the test track in research for railways

The above-stated experimental tests for railways performed on the Test Track of the Railway Research Institute are intended to check the suitability of new

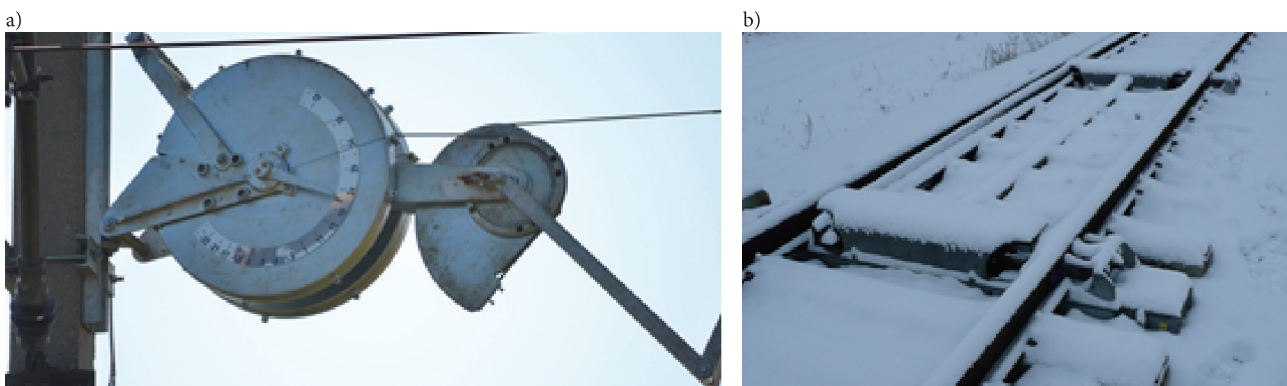


Fig. 9. Testing infrastructure elements a) equipment for catenary tensioning b) equipment for hydraulic turnout interlocking [own elaboration]

or modified technical solutions which, in effect, are designed to improve the operation of rail transport. They are organized in all fields of railway operation and answer developmental needs. New structural solutions in basic fields of railways should be highly reliable and smooth, which then ensures full safety of the train. This requires comprehensive tests in conditions similar to regular operation. This can be satisfied with a suitable research base whose indispensable element is a test track identified with the following qualities:

- the tests are performed in conditions similar to regular railway traffic, without mutual interference,
- depending on the goal, the conditions for testing can be controlled properly,
- thanks to creation of the same conditions which can be easily defined, it is possible to conduct comparative tests which allow objective assessment of the condition and technical progress of facilities and research processes,
- continuous testing and quick commencement of testing shorten the waiting time for results,
- thanks to testing, it is possible to verify the results of analyses and laboratory tests as well as to create standard operating conditions,
- testing allows new measuring methods to be developed,
- the research process allows the assessment of suitability and appropriateness of new technical solutions, structural elements and new materials in railways [2–6, 8].

9. Conclusions

Innovation is a development which requires us to take courageous decisions, often departing from the acknowledged and previously accepted solutions. Technical progress is unstoppable and the rejection of this progress may affect competitiveness. Widely used digital tools, which have long been used in the process of designing new elements of the railway infrastructure, as well as new structural solutions for the rolling stock are an example of the complete approach to design, starting from concept and performance tests. All of this serves to create a performance test model and test run models along with crashes. Although these technologies are used on a large scale and account for an indispensable element of the process of designing, constructing, testing and using, they do not entail resignation from field tests. Such tests are used to verify new solutions, which is related to the considerable responsibility of railway structures for safety.

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