

METHODS OF ACCEPTANCE TESTS OF RAILWAY TRAFFIC CONTROL EQUIPMENT IN POLAND

В даній статті наведено метод обслуговування та тестування колійних пристроїв автоматики, що використовуються на залізницях Польщі. Періодичність технічного обслуговування обладнання визначено відповідно вимогам міжнародних стандартів. Наведено результати перевірки колійних пристроїв автоматики, що була виконана відповідно цим вимогам.

В данной статье представлен метод обслуживания и тестирования путевых устройств железнодорожной автоматики, используемых на железных дорогах Польши. Периодичность технического обслуживания оборудования определена в соответствии с требованиями международных стандартов. Представлены результаты проверки напольных устройств автоматики, выполненной в соответствии с этими требованиями.

The paper presents method of carrying out and scope of tests preceding acceptance of railway traffic control equipment for application in Polish State Railway (PKP). Terms of commissioning of equipment manufactured for railways are imposed by international standardization committees. The method of testing presented results from these recommendations.

Introduction

The railways commonly use technical systems aimed at maintaining a reliable and safe traffic handling. Correct operation of railway transport is largely dependent, among other factors, of reliability level of elements and devices and the entire railway traffic control systems. Generally, the term reliability means ability to maintain predetermined parameters in certain operating conditions and within the preset time of operation. A function of railway traffic control system reliability is performance and safety of railway traffic itself.

Because of safety and in accordance with the present mandatory provisions (protection against collision resulting in protection of human life), equipment and systems of railway traffic control belong to a group of required very high reliability level. Thus, the development of railway traffic control systems required definition of principle of safe system construction. For this purpose, a principle of «fail-safe» was formulated.

Requirements concerning safety of the systems depend of their application (especially of their influence over reliability and safety of railway traffic). The railway traffic control systems (not to be confused with train traffic control, belonging to a so called supervisory system), having a direct influence on traffic safety are devices belonging to a so-called primary level, and namely:

- station switching equipment
- line blocks
- level crossing signals

- train location systems

The above named systems operates on railways for many years and they are produced (depending of technical progress at the time of their installation and present needs of this particular railway line at the time) in various technologies. However, these technological differences put aside, they have to co-operate.

The aim of this paper is the analysis of method of carrying out and scope of tests preceding acceptance of railway traffic control equipment and development of recommendations concerning terms of commissioning of this equipment.

Safety and reliability in accordance with the European standards

The fail safe principle assumes for all equipment, from mechanical to relay based ones, that a safe system should be constructed in such a way as to ensure that a single malfunction of any of its subassemblies (element of the system) results in lighting a more safe light on the signal (for example, burning out of a green light should result in lighting of orange light).

Introduction of modern (frequently now based on computer technique) railway traffic control equipment, ensuring high operational safety of the entire systems increase safety requirements.

Implementation of this technology required a new definition of safety principles for railway traffic control systems. First of all, in this case, besides the safety of equipment part of the system (hardware) also software safety must be taken into ac-

count. Secondly, these systems are built in a system and software redundancy and with «voting» output systems (such as 2 of 3).

In a shortest way, we may say about these systems' safety that in accordance with European standards, we assume a probability of occurrence of a single malfunction and on this basis SIL – Safety Integrity Levels are determined – Tab. 1. This analysis is to be performed by investigating causes and possibilities of occurrence of each particular malfunction and determination of probability of such occurrence. This analysis is a responsibility of railway traffic control equipment manufacturer.

Table 1

**Safety integrity levels
of railway traffic control equipment**

Safety Integrity Level SIL	Description of safety integrity level	System characteristics	Effects of malfunction
4	Very high	Railway traffic control	Loss of life or health
3	High	Check of train's completeness	Wounds
2	Medium	Railway traffic handling	Contamination of environment
1	Low	Passengers' information	Damaging of system's properties
0	Not related with safety	Railway management	Lack of effects

Whereas the railways' responsibilities include:

- determination of functional requirements (independently of technical realization);
- determination of acceptable risks.

Regardless of technical solution applied, the reliability requirements for railway traffic control equipment impose on their operators an obligation to perform acceptance tests, as well as monitoring of equipment's operation during its normal work.

For the safety's sake, the railways always used to apply its internally developed, own requirements for railway traffic protection equipment. These requirements were applicable both for tests of equipment to be used in railways, and also for tests during operation of this equipment.

Reliability requirements, as well as technical parameters and technical conditions of perform-

ance and commissioning of all equipment produced for railways (including railway traffic control equipment) are determined by the provisions of International Association of Railways UIC and European Standardization Committees CEN and CENELEC [1; 2]. These provisions determine also methods for acceptance and operational tests. In Poland, the principles governing issuance of certificates of operational acceptance for railway traffic control equipment are established in an Ordinance of the Minister of Transportation [3]. The Ordinance uses a term «equipment designed for railway traffic handling». In Poland such certificates are issued by the Chief Inspectorate of Railways (GIK). The railways management applies for issuance of operational acceptance certificate to the Chief Inspectorate of Railways, enclosing results of tests performed by an organization unit authorized to perform such tests as are necessary to obtain an operational acceptance certificate [4–6].

Following the above mentioned Ordinance, the acceptance tests for railway traffic control equipment (both for laboratory and experimental tests) including besides European Standards also requirements of Polish Standards and Branch Standards are performed by the Institute of Transportation at Technical University of Silesia, as an independent (mainly from manufacturers) scientific and research body authorized for carrying out the tests. The Ordinance mentions also the Railway Scientific and Technical Center (CNTK) in Warsaw where the railway traffic control equipment is concerned.

Obtaining an operational acceptance certificate is preceded by the following test and inspection procedure:

- review of manufacturer's application;
- review of documents of quality assurance;
- specification of requirements for the system;
- ascertaining of safety proof and its verification;
- preparation of a normative document;
- preparation of environmental and functional test program;
- carrying out the tests;
- test report that should include the following:
 - fulfillment of climatic conditions, temperature, humidity;
 - fulfillment of mechanical conditions: vibrations, impacts;

- fulfillment of electrical conditions: voltage variation, electromagnetic noise, electrical traction;
- fault analysis: FTA (fault tree), FMEA (fault effects);
- preparation of opinion about the equipment.

Laboratory tests performed on real railway traffic control equipment are not always possible to be carried out, and their results may not be reliable enough to be «transferred» to normal operation. Whereas the tests performed in «real» operating conditions on railway lines are (mainly because of safety reasons), very difficult and time-consuming.

A good compromise is overlapping of both method of tests and inspections. Such a possibilities are provided by an experimental site of Polish State Railway consisting of an experimental track in Żmigród. The tests performed on an experimental track may take place in conditions close to real ones and do not collide with the normal railway traffic (and vice versa) while the duration of test cycle is shortened and there exist a possibility to test at the same time various engineering designs of railway traffic control equipment from various manufacturers.

The acceptance tests are completed by the Chief Inspectorate of Railways issuing an operational acceptance certificate for a given piece of equipment or railway traffic control system. The applicable standards recommend to use the term „safeness» as a property characterized by the fact that a malfunction does not create hazardous situa-

tion [7; 8]. This certificate, together with a safeness statement issued by the manufacturer and with declaration about compliance with standards, authorizes application of this equipment on Polish State Railway. Issue of certificate do not release the manufacturer from his responsibility for safety of his product.

Foreign manufacturers provide their safeness statements in Polish. Safeness statement (prepared in a written form) contains, besides information concerning function of the equipment, determination of safe states and manufacturer’s operation recommendations related with safeness of the railway traffic control equipment, determination of risk level at potential malfunctions and list of tests carried out by the manufacturer together with equipment safeness analysis.

Acceptance tests require a mutual cooperation of manufacturer, the unit that performs the tests and the one that issues the operational acceptance certificate. It takes place in accordance with the recommended standards and so-called cyclic model of engineering a safe equipment. This model (fig. 1) takes into account the following phases: engineering, testing and operation. Each revision resulting from the remarked deviations from the required safeness requirements, malfunctions or even withdrawal of certificate requires return to the beginning of engineering. One has to be aware of the fact that a new version of equipment (after modification) does not necessarily have to obtain the certificate.

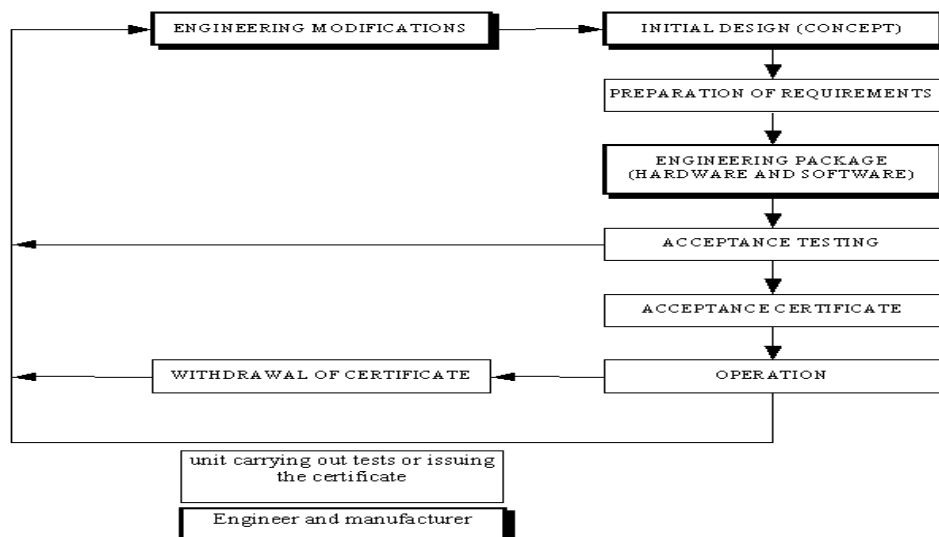


Fig.1. Cyclic engineering model

Method of testing

Method of testing should determine normal operating conditions (sometimes different for various

pieces of equipment), such as ambient temperature, rate of its changing, relative humidity, atmospheric pressure, rated supply voltage, power consumption, operating position, time of readiness for operation and type of operation – most often it is a continuous operation) as well as normal test conditions. Test methods recommend verification of compatibility with the manufacturer's engineering documentation of the following: dimensions, weight, materials used, workmanship quality, signaling of power supply and marking of equipment (product name, manufacturer's name, product number/year of production and technical inspection mark).

The railway traffic control equipment testing methods differentiate between environmental and operational tests. Environmental tests should be carried out in experimental laboratories, while operational tests (the best of all) on experimental track.

The period of environmental tests results from a normative duration of each test and trial, while operational tests should last for 12 months, including all seasons (all operating conditions existing in Poland).

Subassemblies and equipment damaged during these tests should be replaced by new ones.

The railway traffic control equipment tested is classified, according to its application, as outdoor or indoor type equipment. In accordance with this classification, the tests take into account environment conditions concerning locations respectively unprotected and completely protected against environment conditions (controlled environment). Environmental factors may be divided into:

- climatic conditions (ambient temperature, rate of its changing, relative humidity, atmospheric pressure, sunlight, precipitations – rain, snow, sleet, rain temperature, rain intensity, movement of ambient air, condensation, freezing and frosting);
- chemical influences (salts, gases, fumes, greases and oils);
- substances with mechanical impact (sand, dust);
- mechanical conditions (vibrations – amplitude, acceleration, frequency).

The environmental tests verify the following features in this order: workmanship and outer look, marking, dimensions, weight, assembly, power supply signaling, power supply voltage, protection against unauthorized access, serviceability, time of start up, operation durability for given working conditions, reliability, operational strength, safety

of use. «Active» checks should be performed in the following order: initial stabilization, initial visual inspection and verification, inspection/exposure itself, final stabilizing, final visual inspection and verification. Time of tests for each type of exposure is determined from the moment when the device is entirely exposed to the preset value of exposure factor. Upon occurrence of a malfunction, its cause should be determined and it should be stated whether the device has «responded» in a safe way (in accordance with the safeness statement provided by the manufacturer). It is acceptable to combine the tests (combined tests) and make use of results obtained in the tests performed earlier.

Test results are deemed to be successful if after their completion the device in question is fully operational with safeness conditions fully complied with.

Verification of equipment's resistance against operation conditions refers to the following:

- resistance against sinusoid vibrations and jolts in a jolting and vibration machine;
- resistance against cold in the climatic chamber;
- resistance against dry heat in the climatic chamber;
- resistance against permanent humid heat in the climatic chamber resistance against atmospheric corrosion in an appropriate testing apparatus. Term «appropriate testing chamber» should be understood as standard apparatus or an apparatus produced for the individual purpose of this particular test, in accordance with the requirements of applicable standards. It is not possible to perform a single corrosion test – an approximate for maritime climate is slaty mist, industrial «climates» may be imitated by humid air with sulfur dioxide;
- resistance against water in an appropriate testing apparatus (this test should be divided into two tests: «falling drops» test and «immersion» test);
- resistance against sunlight in an appropriate testing apparatus;
- resistance against external electromagnetic fields in an appropriate testing apparatus;
- resistance against traction currents;
- resistance against electromagnetic noise.

Operational tests are carried out in normal environmental conditions and in real time. The equipment should be installed and operated in accordance with the manufacturer's instructions. The

tests should include verification of equipment's operation both when it fulfills required functions and in waiting time in standby conditions.

The operational tests should verify ability to operate (in real conditions and with simulation of malfunctions), serviceability, maintainability and functional compatibility with other equipment. Upon occurrence of a malfunction, its cause should be determined and it should be stated whether the device has «responded» in a safe way (in accordance with the safeness statement provided by the manufacturer). In the operational tests, the «active» tests should be performed in «in service» situations for a normal passage of rolling stock with stopping, and subsequently with backing, continuing of travel forward or with backing and continuing of travel forward.

Standards developed by appropriate committees put an enormous emphasis on correctness, reliability and safeness of software of more and more frequently implemented computer based railway traffic control systems. These recommendations concern appropriate organization of software preparation and verification processes, as well as they provide requirements for the structure of software and tools being used.

The operational test program discussed above applies equally to the relay and electronic based railway traffic control equipment and the computer based ones. Verification of required railway traffic control equipment or system functions in the operational tests includes also analysis of correctness and safety of software part. These test however should be completed with a laboratory software testing in the situations exceeding normal operation conditions.

Conclusions

Description of tests performed should be maintained on a durable information media and should be marked with the name of institution performing the testing, name of equipment, basic data of equipment, description of test methods, list of reliability indices determined time of test duration, method of recording and analysis of malfunctions, principles governing the preparation and interpretation of test results and test sheet, with marked date and time of starting the tests, real duration of

tests, environment conditions, date and time of malfunction occurrence, type and cause of malfunction, duration of idle time caused by discovery and removal of the malfunction and summary number of malfunctions during the tests.

An important issue, although exceeding the presented scope, is the issue of operation tests (monitoring of equipment operation during their normal work and recording of malfunctions in the Equipment Check Log) and evaluation of reliability of railway traffic control equipment and systems on this basis.

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