Journal scientific and applied research, vol. 28, 2025
International Journal

ISSN 1314-6289 (Print)
ISSN 2815-4622 (Online)

Original Contribution

THE ROLE OF THE SYSTEMATIC APPROACH IN DETERMINING THE RELIABILITY OF TECHNICAL SYSTEMS IN A TRANSPORT LOGISTICS SYSTEMS

Nikolay N. Nedev

DEPARTMENT OF ENGINEERING LOGISTICS, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, SHUMEN 9712,115, UNIVERSITETSKA STR., E-MAIL: 2472291008@shu.bg

ABSTRACT: *This publication defines the scope of inspections of railway facilities and devices, as well as the methods for recording results and taking action to remedy malfunctions. The re-liability of systems in transport logistics is key to the efficiency and safety of processes. It ensures that all components of the system work smoothly and predictably.*

KEY WORDS: *Reliability, Technical facilities, Dependability.*

1. Introduction

During the inspection, the technical condition of the facilities is assessed, and it is checked whether the measured parameters comply with the permissible norms and requirements [5]. Measurements are carried out only with approved and verified instruments. The commission must be objective and reflect the real condition. Every member of the commission bears personal responsibility if they present biased data or fail to register malfunctions. If malfunctions that endanger the safety of transport are found, the commission is obliged to immediately take action to eliminate them. If this is not possible, the operation of the facility must be suspended, and the necessary activities, deadlines, and responsible persons for eliminating the malfunctions are determined.

2. Related work

The reliability of technical systems in transport logistics must meet three mandatory conditions:

- Availability: The system must be available for use when needed. This includes minimal downtime due to damage or maintenance;

- Reliability (failure-free operation): The system must operate without fail-ure for a specified period of time under given conditions. This is especial-ly important for components that are critical to safety;

- Maintainability: The system must be able to recover easily and quickly af-ter a failure. This includes the availability of spare parts, qualified person-nel, and clear repair procedures.

The reliability of technical facilities in logistics transport systems is achieved through regular maintenance, the use of high-quality equipment, staff training, and the implementation of technologies for monitoring and predicting damage [1].

High reliability in logistics systems is achieved through:

- Proactive maintenance: Instead of waiting for a breakdown, strategies such as preventive and predictive maintenance are applied. This includes regular inspections, replacement of worn-out parts, and data analysis to predict potential failures;

- Quality design and production: The use of high-quality components and materials, as well as the application of strict quality control during transport op-erations, are essential for building reliable systems;

- Redundancy: The implementation of duplicate systems or components that can take over the functions of the main ones in case of their failure;

- Real-time monitoring: The use of sensors and software to monitor the condition of equipment allows for the early detection of anomalies and the pre-vention of major failures.

The reliability of technical systems is of essential importance for modern logistics, as it minimizes interruptions, reduces operating costs, and increases the overall efficiency and safety of operations [1].

2.1. Elements of the technical equipment of an operating point, as part of a logistics transport system subject to revision and control for operation-al reliability.

Inspection of tracks and switches When inspecting tracks and switches, special attention is paid to the following aspects:

A. Tracks:

- Ballast Bed: Contamination should not exceed 40%, and effective wa-ter drainage is crucial.

- Sleeper Frame: Sleepers are to be positioned according to the diagram, allowing deviations of up to 100 mm, with a maximum of three unsuitable sleepers.

- Fastening: Completion and tightness are essential.

- Joints and Joint Connections: These components require strength, tightness, and freedom from "clips."

- Insulated Joints: They are to possess the necessary thermal gap, be robust, and exhibit no "overhangs."
- Rails: Their condition and wear demand assessment.
- Thermal Gaps: Dimensions must align with technical norms.
- Level, Axis, and Gauge: Conformance to norms is mandatory.
- The clearance: Must not be violated.;
- Platforms: Their condition and adherence to clearance and height from the railhead require verification.
- Energy-Absorbing Facilities: The condition of these facilities at the end of dead-end tracks is to be assessed.
- Rail Joints: In straight sections, they should lie at a right angle to the track's axis; in railway curves, a radial alignment is expected.

Fig. 1. Railway Line

B. Switches:

- Ballast Bed: Contamination should not exceed 40%, and effective water drainage is crucial.
- Sleeper Frame: Adherence to the diagram is required, allowing deviations of up to 50 mm, with a maximum of three adjacent unsuitable sleepers.
- Fastening: Completion and tightness are essential.
- Sliders and/or Rollers: These components are to be strong, securely attached, and clean.
- Joints and Joint Connections: Strength and tightness are paramount.
- Switch Elements: Their condition, operation, and the pounding of rail ends demand careful assessment.
- Thermal Gaps: Dimensions must align with technical norms.
- Insulated Joints: These require the necessary thermal gap, robust construction, and freedom from "overhangs."

- Level, Axis, Gauge, and Groove Dimensions: Compliance with technical norms is mandatory.
- Point Adherence: Points must fit tightly against sliders and stock rail wedges, with a maximum gap of 2 mm.
- Manual Switch Locks: (Where installed) Verification involves attempting to reverse the switch in the locked position.
- Switch Numbering: Switches are to bear a permanently written number, with their main position noted as per Regulation № 58.
- Switch Parts: Maintenance dictates these remain free of sand, mud, grass, snow, and ice.
- Wagon Ejectors and Platform Locks: Their condition warrants inspection.
- Switch Rods and Additional Locking Systems: Their condition is to be verified.
- Point-to-Stock Rail Adherence: This requires checking.
- Switch Point Locking System: Its condition is to be checked.
- Lubricators: Their condition requires assessment.

Fig. 2. Track Layout and Switch

2.2. Inspection of safety equipment (SE)

A. Signaling, centralization, and interlocking:

- Traffic Safety Devices: Apparatus equipped with these devices are to be cleaned, closed, locked, and/or sealed.
- Channels and Shafts: These areas require thorough cleaning and drainage.
- Insulated Sections: Cleanliness is essential to prevent interference with rail current circuits.
- Signals: Visibility must comply with Regulation № 58.
- Semaphore Curve & Signal Lights: Both the curve of semaphores and the lights of traffic signals are to be visible and consistent.

- Automatic Semaphore Closing Mechanism: This device must be in proper working order.
- Jumper Connections: The integrity and connectivity of jumper links are to be checked.
- Sealed Buttons: Functionality of sealed buttons for the "Call-on Signal," “BDO” (Remote Opening Button), and “IBPU” (Crossing Device Isolating Button) is to be verified.

Fig. 3. Sealed Call-on Signal Button

- Axle Counters: Their condition and attachment require checking.
- Key-Staff: The serviceability of the key-staff is to be verified.


Fig. 4. Catenary and Traffic Light

Fig. 5. Automatic Crossing Device (APU) Panel

B. Automatic Locomotive Signalling (ALS) / ETCS (European Train Control System) Devices:

- Balises and Coding Devices: Their condition, attachment, and the integrity of their seals are to be checked.
- Cables: The security of their attachment (fastening) is to be verified.

C. Level crossings:

- Manual and Electric Barriers: Inspection includes their operation, mechanisms, boom arms, road traffic lights, and audible alarms.
- Clearance Frame: The condition of the clearance frame and the presence of necessary signage are to be verified.
- Level Crossing Visibility: The overall view of the railway crossing requires checking.
- Electrical Supply and Lighting: Their condition is to be assessed.
- Road Signs and Markings: Road signs, advance warning indicators, road traffic lights, audible alarms, the cleanliness of the flangeways (or troughs/channels), and the integrity of the road surface are all to be inspected.
- Crossing Keeper's Cabin Equipment: The equipment within the cross-ing keeper's cabin is to be checked [2].

2.3. Inspection of the telecommunications system

During the inspection of the telecommunication system, the following requirements are to be considered:

- Station Concentrators and Telephones: These devices must be in good working order, with clear transmission and reception.
- Communication Links: Functionality is essential for all communication links.

- Shunting Loudspeaker Radio System & Talk-back Columns: These systems are to be in proper working condition.
- Passenger Announcement Radio System: This system should be well-oriented, providing clear and audible communication.
- Shunting and Train Dispatcher Radio Connections: These connections must be operational and free from interference with other channels.
- GSM-R Terminals: Both the traffic controller's GSM-R terminals and portable terminals are to be in proper working order.
- Communication Lines and Cables: Their serviceability requires check-ing.
- Wire and Optical Cable Clearance: Conductors and optical cables must maintain a minimum distance of 1 meter from shrub and tree branches.
- Emergency Telephone Columns and Telephones: Their condition is to be verified.
- Aerial Optical Cables, Consoles, and Rollers: Their condition is to be checked.

2.4. Inspection of the contact network

During inspections of catenary facilities, a survey of the entire station is conducted, from the entry signals to the "Station Limit" indicator:

- Non-Traction Transformers: Their condition is checked, with attention to leaks, the presence of grounding, and the integrity of insulators.
- Overhead Turnouts (Air-Switches), Contact Strips, Drop-pers/Fixators, and Electrical Connectors: Their condition requires verification.
- Compensating Devices: These devices are to be checked.
- Catenary Signals: The presence and condition of catenary-specific signals are to be verified.
- Catenary System Components: An inspection of the contact wire, droppers/fixators, stay wires, clamps, insulators, feeders, disconnectors, air gaps, and section insulators is performed, including switching all disconnectors.
- Disconnector Drives and Locking Devices: The condition of drives for motorized and manual disconnectors, as well as their locking mechanisms, is to be checked.
- Clearance: Verification is made that a 2-meter clearance is maintained between live equipment and other facilities, trees, and vegetation.
- Catenary Sectioning Diagram: The presence of an up-to-date diagram for catenary sectioning and disconnectors within the station is to be confirmed.
- Remote Control Panel for Disconnectors: The serviceability of these panels is checked, along with the presence of the "Instruction Manual for Remote Control Panel Operation."
- Section Post: An external inspection of the Section Post is carried out, verifying the serviceability of communication links and the presence of form XXI-01 logbook.

2.5. Inspection of other signals, indicators, and devices

- Distant Indicators: Verification includes their correct placement, cleanliness, and white coloring, as well as the presence of indicators for switches, wagon ejectors, dead-end track limits, and turntables, all in accordance with Regulation № 58.
- Order Disc and Signal Lanterns: These items must display the necessary signal colors.
- Safety Equipment (Traffic Controller): The presence of a serviceable yellow flag in the traffic controller's office is checked.
- Safety Equipment (Switchmen): The presence and good working order of signal accessories for post switchmen are verified.
- Track Safety Devices: The availability and serviceability of detonators, brake shoes (wheel chocks), wooden wedges, manual switch locks, and the matching secrecy of their keys are checked.

2.6. Verification of reporting documents

During each inspection, com-mission members must also verify the condition and proper maintenance of all record-keeping documents, reports, logs, and registers pertaining to the facilities. The inspecting party shall affix their signature to the document [4].

3. Results

A systematic approach to maintaining railway transport safety encompasses every key infrastructure element. This ensures that all components, from physical facilities to technical equipment, undergo regular and thorough inspection, thereby identifying even the smallest potential problems.

4. Conclusion

Monitoring and reliability conditions for technical systems cover a wide spectrum of elements, including tracks, switches, safety equipment, telecommunications, catenary, lighting networks, and other signals and indicators. This process defines not only the scope of inspections but also the procedures for recording results and implementing corrective measures. Particular attention is paid to the objectivity and personal responsibility of personnel within the system, as well as the immediate response to detecting faults that threaten transport safety.

Acknowledgments

This scientific article under project number RD-08-123/07.02.2025 „Research on the application of ergonomics in activities related to engineering logistics“ is funded.

References:

[1] Petrov, N. "Operational Reliability of Risky Technical Systems", Yambol, Publishing Complex “Zhelyo Uchkov”, ISBN 954-9978-26-5, 2002.

[2] Hristov, Hr. "Fundamentals of Safety Engineering", Conference: International Conference on Mathematical Models for Engineering Science ((IEEEAM - MMES'12, at: Puerto De La Cruz, Tenerife, Spain.

[3] Regulation № 58 on the rules for technical operation, train movement, and signaling in railway transport, 2020.

[4] Rules for the technical operation of the railway infrastructure of NRIC, Art. 411.

[5] IEC 60050 (191), International standard for reliability.