MAINTENANCE & DIAGNOSTICS MANUAL

MIREL VZ1

Train Protection System

154VZ1 : 090822 (154-99-SW-4P-VZ)

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2				
3				

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Contents

Document Definition

This Maintenance & Diagnostics Manual for the MIREL VZ1 train protection system is based on the Maintenance & Diagnostics Manual for the MIREL VZ1 train protection system **no. 154-99-SW-4P-VZ dated 15. 6. 2000.**

The following addendums have been incorporated into the manual:

1. **Addendum no. 1 dated 11.10.2000** to the Maintenance & Diagnostics Manual for the MIREL VZ1 train protection system based on equipment technical safety requirements (added in sections: D1 – Non-Continuous Self-Diagnostics, D2 – Continuous Self-Diagnostics, D4 – Preventative Inspection, Failure Signalization).
2. **Addendum no. 2 dated 11. 5. 2004** to the Maintenance & Diagnostics Manual for the MIREL VZ1 train protection system resulting from the approval of Addendum no. 1 to the technical conditions for serial installation of the MIREL VZ1 train protection system (257-00-TW-4P- VZ, 05.03.04).
3. **Incorporation of functionality pursuant to MÁV specifications dated 17. 1. 2006** based on the Set of MÁV Rt Functional Requirements for On-board Train Protection and Vigilance Equipment, (738-06-TW-4P-VZ, 12.01.06), the Specification of Changes to the MIREL VZ1 Train Protection System - Integration of MÁV Rt Functions (412-02-FW-4P-VZ, 15.01.06) and Addendum No. 2 to the Technical Conditions for Serial Installation of the MIREL VZ1 train protection system (257-00-TW-4P-VZ, 16.01.06).
4. **Functionality changes based on ŽSR/ČD specifications** after completion of test operations of v03 software and **expanded functionality pursuant to MÁV specifications for track speeds up to 160 km/h** based on the Set of MÁV Rt Functional Requirements for On-board Train Protection and Vigilance Equipment (738VZ1: 081020).

General Characteristics

The MIREL VZ1 train protection system is the on-board component of a train protection system. The system is designed for use on railway locomotives in conjunction with track and stations equipped with continuous transmission protection equipment and for use on rail lines without such track protection equipment. MIREL VZ1 is an open system that can be expanded in the future to support additional forms of transmitting track information to locomotives. The MIREL VZ1 train protection system secures three critical functions: control, information and protection. It is also designed to monitor train driver vigilance, the transmission of information from track sections to the signal repeater, maximum speed with respect to the locomotive's maximum design speed, maximum speed of the train as a whole and to receive information from track sections. Additional functions include monitoring compliance with the selected direction and actual direction of travel and the option to remotely shut down a locomotive.

The MIREL VZ1 train protection system is composed of a central processor unit, two signal repeaters located in the train driver's cab and two warning horns. A serial data is used to connect the central processor unit and the signal repeaters. Alternatively, the equipment can be operated with a single signal repeater depending on the desired equipment configuration meaning MIREL VZ1 can be operated on single cab or dual cab locomotives. Likewise, the equipment can be configured to enable the transmission of information from track sections to the cabs of locomotives that are not travelling over coded tracks. The MIREL VZ1 train protection system can be used in electric and diesel locomotives and in control cab vehicles.

The locomotive's batteries are used to power the MIREL VZ1 train protection system. MIREL VZ1 equipment is selected and configured based on the voltage supplied by these batteries. Operation and control of the train protection system is performed exclusively from the cab using the signal repeater and other accessories including the vigilance button and various other control elements on the cab's dashboard. No interference into the locomotive's machine room is required when operating the MIREL VZ1 train protection system.

The MIREL VZ1 train protection system is a digital electronic system built on the basis of the most modern electronic components and is conceived as intrinsically safe equipment. Safe actions are ensured using a double processor unit, a series of supervisory loops, dual-channel transmission of information from track sections and dual-channel measurement of speed and track travel. Components used in the central processor unit meet demanding criteria for reliability and robustness. Signal repeaters are created using a dedicated, single-board computer designed exclusively for this purpose.

The MIREL VZ1 train protection system performs non-continuous and continuous self-diagnostics and enables the performance of functional tests to check the correct functionality of all MIREL VZ1 system components and all interactive inputs and outputs. The system is maintenance free apart from functional tests and active controls.

Equipment Configuration

Basic components:

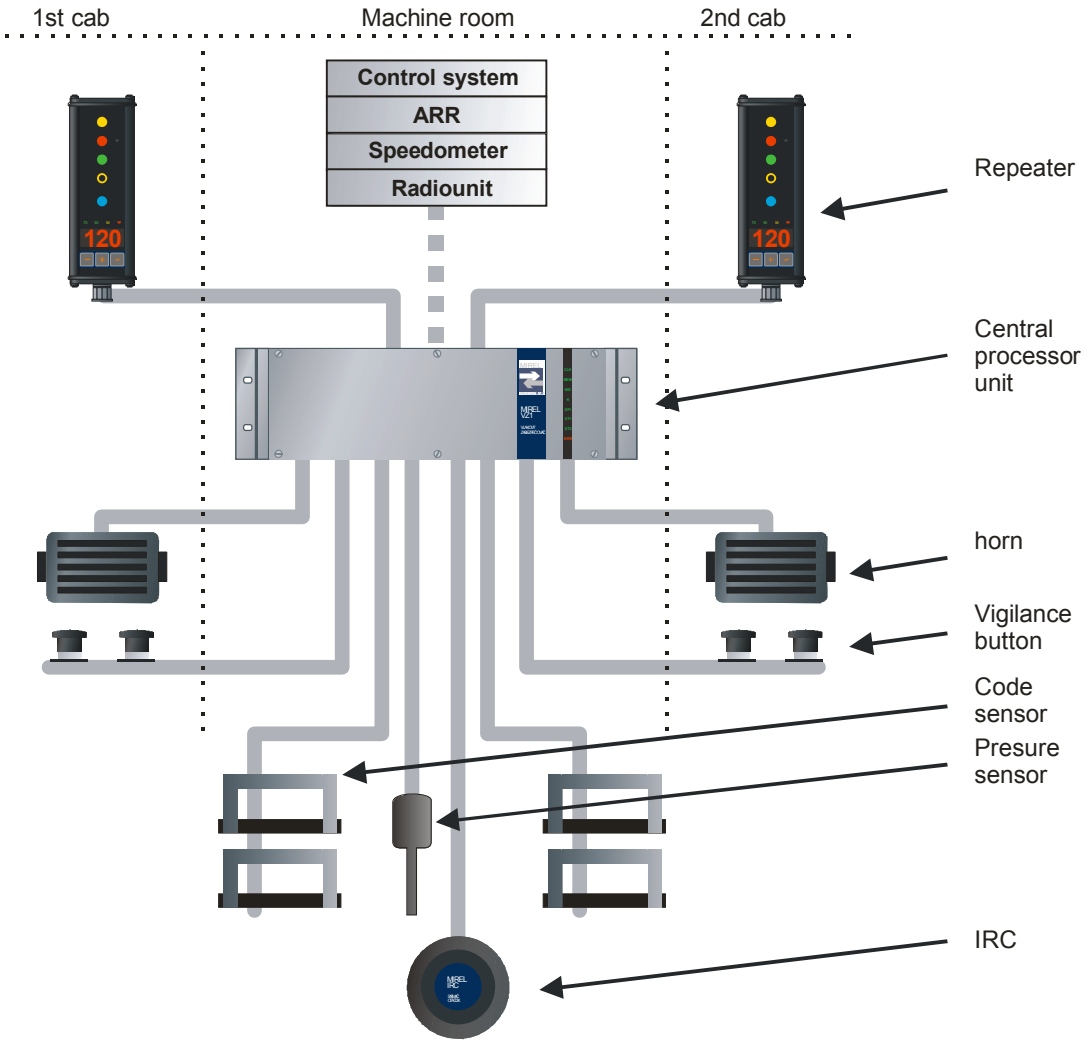
▪ Central Processor Unit	1
▪ Signal repeater	2 (or 1)
▪ Horn	2 (or 1)

Accessory equipment:

▪ Vigilance pedal and button	Number and type depends
▪ Axle revolution sensor	1
▪ Main line pressure sensor	1
▪ Recording equipment	1

Optional equipment:

▪ Code sensor	Alternatives: 4, 2 or 0
▪ Speedometer	Depends on type of locomotive
▪ ARR	Depends on type of locomotive
▪ Control system	Depends on type of locomotive
▪ Radio unit	Depends on type of locomotive
▪ etc.	



Central Processor Unit

The central processor unit secures a majority of functions of the MIREL VZ1 train protection system.

- Filtering and decoding information transmitted from track sections
- Filtering and assessing of signals from axle revolution sensors (measuring speed, travelled track and direction assessment)
- Calculating safety algorithms
- Measuring main line pressure
- Reading inputs (control switches, vigilance button, driving controllers, brakes, direction controller, traction system switch...)
- Generating outputs (control of EPV valve, horns, blue and red aspects)
- Detecting the carrying frequency of train protection system track sections
- Communicating with signal repeaters
- Auto-diagnostics
- Functional testing
- Indicators on the front panel.

There are 8 LED indicators on the front panel of the central processor unit. There are no control components on the central processor unit and no interference into the central processor unit is needed during train protection system operation.

The central processor unit is powered from the locomotive's batteries. The train protection system's power source is protected by a breaker, which is located in the panel housing the locomotive's accessory breakers or at a specific location depending on the type of locomotive. The breaker should not have to be switched in any operational situation. Other components of the MIREL VZ1 train protection system are powered by the central processor unit.

The structural configuration of the central processor unit complies with IEC 297 standards for width measurements, i.e. 19". The height of the unit is designed to match a U module = 44.45 mm. Central processor unit modules are located in an aluminium box. Indicators are located on the front panel of this box. There is a 72-pin industrial type DD connector located on the rear panel. The central processor unit can be put into operation in any position. Placement inside the locomotive depends on the given type of locomotive. Under normal operating conditions and during maintenance work, access to the central processor unit's front panel is required but no disassembly is required.

- **Indicators and serial plate on front panel of the central processor unit**

ZJ1	CLK	Activity indicator
ZJ2	MEM	D1 self-diagnostics indicator
ZJ3	WD	D2 self-diagnostics indicator
ZJ4	K	Indicator for information transmission from track section
ZJ5	SPI	Indicator for SPI bus communication
ZJ6	ST1	Indicator for communication with 1st cab
ZJ7	ST2	Indicator for communication with 2nd cab
ZJ8	ERR	Equipment fault

The full names of these indicators are OIZJ1 to OIZJ8. Abbreviated markings of ZJ1 to ZJ8 have been used in order to make the maintenance manual more user friendly.

Signal Repeater

A signal repeater ensures that information transmitted from the track section is shown in the cab, signals the carrying frequency for the track section code for the train protection system, signals the measures being taken by the train protection system and displays the current maximum speed. The signal repeater is also used by operators to set the train protection system's operating parameters.

A signal repeater is connected using a four conductor cable to the central processor unit; this cable is used to power the signal repeater and for data communication between the central processor unit and the signal repeater.

A signal repeater is finished as an aluminium box or as an accessory installed into the cab's dashboard. There are 4 signal indicators, a blue light, 4 LED indicators, a three-digit alphanumeric display and three control buttons on the front side. If installed in an aluminium box, flexible cabling is attached to the lower section of the box and the signal repeater itself is anchored on rotating components allow it to be positioned at an angle from -30° to +210°. The cabling is always on the back side for dashboard-installed variants. The working position of a signal repeater is vertical.

This train protection system component is active in the cab where the control switch is switched on.

- **Indicators and control elements on the signal repeater's front side**

NO1	In working mode "PRE" indication of a yellow aspect In working mode "MEN", indication of required decrease in brake line pressure
NO2	Indication of a red aspect
NO3	Indication of a green aspect
NO4	In working mode "PRE", indication of the hollow ring aspect In working mode "MEN", indicator of the increased speed mode
NO5	Indicator of train protection system maintenance
NO6	Light intensity sensor
NO7	Indicator for 75 Hz carrying frequency
NO8	Indicator for 50 Hz carrying frequency
NO9	Indicator for MANUAL / MÁV
NO10	Indicator for decreasing the maximum allowed speed, Stopped indicator
NO11	Three-digit alphanumeric display
NO12	MINUS button
NO13	PLUS button
NO14	CONFIRM button

The full names of these indicators are OI1NO1 to OI1NO14 and OI2NO1 to OI2NO14. Abbreviated markings of NO1 to NO14 have been used in order to make the maintenance manual more user friendly. Differentiation between different signal repeaters is clear from context.

Equipment Diagnostics

MIREL VZ1 train protection system diagnostics involve four levels

D1	**Non-continuous self-diagnostics**
D2	**Continuous self-diagnostics**
D3	**Functional test**
D4	**Preventative Inspection**

The first two levels (D1 and D2) are resolved automatically using diagnostic tests of individual equipment components. If a fault is detected, operators are altered and the equipment is placed into safe mode. If the fault does not allow the train protection system to continue to operate, steps are taken to prevent further operation. Operating repairs (S1) must be performed if a fault is detected in the equipment. Maintenance repairs (S2) are needed if a fault repeatedly appears.

A functional test (D3) of the equipment must be performed by the operator's trained technicians. A functional test checks the overall functionality of the system, meaning the functionality of indicators, buttons, input and output circuits and interaction with other locomotive equipment (including driving controllers, EPV, axle revolution sensors, pressure sensor, etc.). Operating repairs (S1) must be performed if a fault is detected in the equipment. Maintenance repairs (S2) are needed if a fault repeatedly appears.

Preventative inspection (D4) of the equipment is performed periodically by the manufacturer of the train protection system or another party trained and authorized by the manufacturer. In addition to performing the functional test, an active test involves a more in-depth check of the equipment (testing input code filters, reading internal train protection variables, checking the condition of input and output circuits and checking the condition of equipment interacting with the train protection system). This check is performed to evaluate complete functionality and wear and tear. Maintenance repairs (S2) are needed if a fault appears.

Every technician conducting train protection system diagnostics must be instructed with respect to occupational health regulations, must be verifiably trained to perform these activities and must have verifiable authorization to perform the individual levels of equipment diagnostics.

Non-Continuous Self-Diagnostics

Performed by:

The train protection system performs these diagnostics automatically without any operator or maintenance interference.

Deadline:

Every time the MIREL VZ1 train protection system is switched on

Description:

The train protection system starts up once the battery power source of the locomotive is switched on. Every time it switches on, the train protection system performs an self-diagnostic test, which checks the integrity of the equipment itself, the accuracy of configuration parameters and the basic functionalities of the equipment. The time to complete this self-diagnostic test is around 90 seconds plus the time needed to perform the EPV functionality test. The EPV functionality test is performed the first time the locomotive's brakes are released. D1 non-continuous self-diagnostics are performed in every working mode of the train protection system. They first run when the system is powered up and then repeat every 8 to 12 hours thereafter. D1 self-diagnostics are automatically triggered (the operator does not have to do anything) based on a specific algorithm:

- The first time the locomotive stops if 8 hours have passed since the previous D1 self-diagnostics
- If (theoretically) a locomotive does not reach a speed of zero at an interval of 8 to 12 hours after the last D1 self-diagnostics, D1 self-diagnostics cannot be run and the equipment detects a fault
- If the equipment is using MÁV specifications, is in an operating mode and receives a speed order to 0, the repeated launch of the D1 non-continuous self-diagnostics is blocked until another speed order is transmitted.

The repeated start of a D1 self-diagnostics can be deferred. The operator is notified of a repeated start of D1 self-diagnostics 15 seconds before they start by a blinking D1 message on the signal repeater and an audible signal. During this interval, the operator can press the CONFIRM button to defer the self-diagnostics for 15 minutes. If CONFIRM is not pressed within this initial shorter period of time, the self-diagnostics are started automatically and no other procedure can be performed until this test is completed.

When a D1 test is underway, code sensor transmission for track section information is blocked for a period of around 90 seconds, regardless of if the equipment is in PRE or MEN mode.

A D1 non-continuous self-diagnostics include diagnostics of outputs from the controllers in the cab. The following control elements are involved:

- Control switch in the cab
- Direction lever or other equipment used to determine direction
- Input from the pressure switch for auxiliary brakes

The operator is obliged to perform the manoeuvre shown on the control elements every time a D1 test is run:

- Place the control switch into the SWITCHED OFF position while the control switch in the other cab is also switched off
- Place the directional lever into the NULL position
- Place the directional lever into the FORWARD position
- Place the directional lever into the BACKWARD direction

- Set the auxiliary brakes (when the locomotive's air tanks are full)
- Release the auxiliary brakes (when the locomotive's air tanks are full)

The sequence of control element manoeuvres is not binding; directional lever and auxiliary brake manoeuvres must be performed with the control switch turned off. Control element manoeuvres only need to be performed from one of a locomotive's cabs. The procedure for executing various self-diagnostic test steps is indicated on the signal repeater in the 7-segment column in front of a D1 signal. If the segments light up, the given step has not been performed. If the given segment switches off, the conditions for the given step have been met. The meaning of the individual segments from top to bottom is as follows:

Position	Description
1st row	Signal repeater communicates with central processor unit
2nd row	Both control switches in the null position
3rd row	Directional lever in the active cab has reached null position and 1st direction (forward or backward depending on the type of locomotive)
4th row	Directional lever in the active cab has reached the null position and 2nd direction (forward or backward depending on the type of locomotive)
5th row	Auxiliary brakes have met both conditions (engaged and released)
6th row	The first section of the EPV diagnostic test (opening through Channel M) led to the desired drop in pressure in the main brake line
7th row	The second section of the EPV diagnostic test (opening through Channel C) led to the desired drop in pressure in the main brake line

After completing all of the steps, the "D1" indicator on the signal repeater will go out and the equipment will be placed into a working mode. The operator is notified of the obligation to perform the manoeuvres with the control elements and to perform the EPV functionality test by four short audible signals and the "D1" notation on both signal repeaters. The train protection system cannot be activated in either cab if the operator does not complete the required manoeuvres or the EPV test. The "D1" notation will remain displayed on the signal repeater.

List of tests during non-continuous self-diagnostic checks:

Program integrity check – the equipment counts the check sums in memory used to save the program and compares them to the expected values. Equipment fault **E03, E40, E42, E43** or **E44** will appear if a memory fault occurs. The equipment is not functional during this test.

Integrity check for program parameters – the equipment counts the check sums in the memory used to store program parameters and compares them to the expected values. Equipment fault **E02** or **E03** will appear if a memory fault occurs. The equipment is not functional during this test.

Functionality check for working registries in processors – this is a read and write test for all bit combinations of data in all registries in all processors. Equipment fault **E41** will appear in the event of a registry fault.

Control of RAM memory functionality – this is a read and write test for all bit combinations in all memory cells in all processors. Equipment fault **E41** will appear in the event of a RAM fault.

Check for communication between PMM and PMC processor modules of the central processor unit – the PMM processor sends a SYNC packet to initiate communication with the PMC processor module. Equipment fault **E06** will appear if communication is not established within 5 seconds. The equipment is functional during this test.

Check for communication between central processor unit and signal repeaters – the PMM processor module in the central processor unit sends a SYNC packet to initiate communication with the signal repeaters. Equipment fault **E04** or **E05** will appear if communication with the signal repeater in the active cab is not established within 5 seconds. The equipment is functional during this test.

Check of transmission routes for information received from the track section – the equipment tests its transmission filters, connections to sensors and sensors themselves (if sensors allow for this feature, e.g. MIREL SN class sensors) along both transmission channels. This test involves 24 steps, which gradually combines the following parameters:

Transmission channel:	M, C
Carrying frequency:	50 Hz, 75 Hz
Transmission route from cab:	1, 2
Signal intensity:	Weak, Moderate, Strong

The transmission route test is only completed in full if the locomotive is stopped on a track section with no signal transmission. If the equipment detects a 50 Hz or 75 Hz carrying frequency in the track circuit, the carrying frequency test step will be skipped. Equipment fault **E06** will appear if a fault is detected.

The equipment is functional during this test. Track section information is not transmitted if the equipment is switched into the PRE or MEN mode during the transmission route test.

Check for EPV emergency brake functionality – the equipment performs a check of EPV controls in both channels. This check involves two steps. When the brakes are released on the locomotive for the first time, the EPV slightly opens first using channel M and then using channel C. The equipment assesses the drop in pressure in the main line and compares it to the expected values. Equipment fault **E08** will appear if test conditions are not met. The equipment is functional during this test.

Integrity check for configuration parameters – the equipment counts the check sums in memory used to store configuration parameters and compares them to the expected values. Equipment fault **E33** will appear if a memory fault is detected. The equipment is functional during this test.

Test Report:

Not issued.

Resolving Discovered Faults:

If a fault is detected during any non-continuous self-diagnostic test, switch the train protection system breaker off for at least 1 second and then back on to reinitialize the train protection system. **If the indicator lights again, this is an equipment fault that prevents the train protection system from operating properly.** Operational repairs (S1) are required.

D2 - Continuous Self-Diagnostics

Performed by:

The train protection system performs these diagnostics automatically without any operator or maintenance interference.

Deadline:

Continuously during train protection system activities

Description:

The train protection system performs continuous self-diagnostics using its watchdog supervisory loops, comparing assessments of channels M and C and performing other routine tests that monitor proper functioning of the train protection system. The train protection system continuously compares the results of the main (PMM) and comparison (PMC) processor modules. If a difference is detected by continuous self-diagnostics, an equipment fault is indicated and the train protection system is placed into safe mode. The train protection system also continuously diagnoses central processor unit communication with the signal repeaters. The train protection system is blocked from operating if a serious communication fault involving the signal repeater in the active cab occurs (cab where control is switched on). The equipment may operate with limited functionality if a communication fault with the signal repeater in the inactive cab is detected; the train protection system requires operational repairs in this case.

Tests performed during continuous self-diagnostics:

Test of supervisory loops (watchdog) – both processor modules in the central processor unit and each signal repeater are equipped with a pair of supervisory loops. One monitors proper processor activity and the other monitors processor activity in conjunction with other circuits. Supervisory loops monitor proper functionality of the individual processors, proper program execution, the activity of timers and the functionality of processor interruption systems. The supervisory loops operate at intervals of 16 ms and 100 ms. If a fault in a supervisory loop is detected, the given functional block is re-initialized, which generates an error for the entire equipment. Equipment fault **E01** will appear if there is a fault in a central processor unit processor module (PMM or PMC). Equipment fault **E03** will appear if the fault occurs in a signal repeater.

Integrity test for defined operating parameters – signal repeaters continuously monitor compliance between defined parameters and the valid parameters in the central processor unit. This concerns setting the working mode and the defined train speed. The time limit for checking defined and valid parameters is 1 second. The equipment detects an integrity fault in the defined parameters if the parameters do not match during operation (e.g. a communication error between the central processor unit and a signal repeater) or if the central processor unit does not confirm the acceptance of newly defined parameters. Equipment fault **E31** or **E03** will appear if the equipment detects an integrity fault in the defined parameters.

Communication functionality test – every unit continuously monitors the functionality of RS485 data communication. The equipment will announce a communication fault if the PMC processor module or either signal repeater does not accept the correct data packet from the PMM module for a period of more than 5 seconds. The same occurs if the PMM

processor module does not receive the correct packet response after 50 prompts. Equipment fault **E04, E05, E06, E03** or **E00** will appear in this case.

Test of train protection system activation integrity –equipment continuously checks the central processor unit channels M and C with a frequency of 10 Hz. Equipment fault **E10** will appear if different results are detected during train protection system activation.

Test of maximum allowed speed assessment integrity – the equipment continuously checks the results of central processor unit channels M and C with a frequency of 10 Hz. Equipment fault **E14** will appear if a deviation of greater than 5 km/h is detected during the maximum allowed speed assessment for more than 180 seconds.

Test of signal aspect transmission integrity - the equipment continuously checks the results of central processor unit channels M and C with a frequency of 10 Hz. Equipment fault E15 will appear if the results differ during the decoding of the transmitted signal aspect or speed order for a period of longer than 20 seconds.

Speed measurement test – speed measurements are performed using the four-channel axle revolution sensor. In both assessment channels (M and C), the immediate actual speed measured from channels 1 and 2 as well as 3 and 4 is calculated. These calculated speeds are compared and each assessment channel works with the higher of the two calculated speeds. Equipment fault **E20** will appear if the difference between the measured speeds is more than 20 sensor pulses after 3 seconds. A comparison of results takes place in both assessment channels. Equipment fault **E25** will appear if the difference between the speeds measured in channels M and C is more than 2 km/h for longer than 10 seconds.

Pressure measurement test – the pressure sensor in the main line is connected to the equipment using a 4 to 20 mA signal circuit. The equipment continuously tests the upper and lower limit values. Equipment fault **E24** will appear if a limit is exceeded. A mutual comparison of results takes place in both assessment channels. Equipment fault **E26** will appear if the difference between the pressures measured in channels M and C is more than 0.2 bar for longer than 20 seconds. The final pressure test in the main line checks for a match between pressure and locomotive movement. Equipment fault **E12** will appear if locomotive speed is greater than 20 km/h and pressure in the main line is less than 3.5 bar for longer than 120 seconds.

Test of actual direction of travel assessment – the same as for speed measurements, the direction of travel assessments also tested. Equipment fault **E21** will appear if the direction assessments do not match for longer than 3 seconds.

Check of EPV during train protection system activation – the EPV valve is opened using channel M if the train protection system is activated. The drop in main line pressure is measured and compared with expected results. Equipment fault **E11** will appear if the drop in main line pressure is insufficient and the EPV will be opened using channel C as well. The pressure should drop below 4.5 bar within 5 seconds while in 10 seconds it should be less than 3.5 bar.

Test of axle revolution sensor power – the equipment checks for proper power draw by the axle revolution sensor. Equipment fault **E22** will appear if power draw is low (power connection is lost) or if power draw is excessively high (power connection short circuit).

Test of main line pressure sensor power – the equipment checks for proper power draw by the main line pressure sensor. Equipment fault **E23** will appear if power draw is low or if power draw is excessively high.

Test for processor decoding and execution of instructions – the correct processor decoding and execution of used subsets of the instruction file is tested by running a special diagnostic portion of the program, which is performed cyclically in 4 parts with a mutual comparison of results. The period for performing a single cycle is 100 ms. The duration of the test for all bit combinations of input data is 26 seconds. Equipment fault **E30** appears if an error in decoding and executing instructions is detected.

Test for re-launch of D1 self-diagnostic check – equipment fault **E32** will be shown if the equipment is prevented from running repeated D1 non-continuous self-diagnostics within an interval of 8 to 12 hours from the last such test (due to the fact that a speed of zero has not been reached.

Test Report:

Not issued.

Resolving Discovered Faults:

If a fault is detected during non-continuous self-diagnostics, switch the train protection system breaker off for at least 1 second and then back on to reinitialize the train protection system. **If the indicator lights again, this is an equipment fault that prevents the train protection system from operating properly.** Operational repairs (S1) are required.

D3 – Functional Test

Performed by:

Technician trained by the train protection system's operator

Deadline:

Regularly, every six months with a tolerance of ± 1 month. The performance of a Preventative Inspection is a suitable replacement for the performance of a Functional Test. At least 3 functional tests must be performed in each 24-month preventative inspection cycle. A new six-month period commences if a functional test is performed unexpectedly.

Description:

The goal of the functional test is to verify the accuracy of all basic functions of the train protection system. The functional test includes 3 sections:

A. Preparation and basic functionality (7 steps)
B. Functionality of setting parameters (18 steps)
C. TEST diagnostic mode (63 steps)

A majority of the steps in sections B and C are performed separately for each cab. In a twin cab configuration, the functional test has a total of 152 steps; in a single cab configuration the functional test has a total of 88 steps.

The special TEST diagnostic mode for the train protection system is used to perform Section C of the functional test. This mode is activated in the cab by pressing the CONFIRM button and closing the control switch. The locomotive's speed must be zero and the equipment must be in ZAV mode or in a mode there D1 self-diagnostics are not underway. Press the PLUS button to complete one step and move on to the next step in Section C. It is possible to return to the previous step by pressing the MINUS button. An output is generated by pressing the CONFIRM button. Turn the control switch off to end TEST mode.

The check of connected input parameters (speed and main line pressure) is performed in ZAV mode or when D1 self-diagnostics are not underway. Display NO11 shows the speed of the locomotive with a precision of 1 km/h when pressing the MINUS and CONFIRM buttons simultaneously; display NO11 shows the main line pressure with a precision of 0.1 bar when pressing the PLUS and CONFIRM buttons simultaneously.

The worksite must be equipped with MIREL VZT test equipment to perform a full functional test of the equipment.

The following steps must be performed in a functional test:

Step	Tested	Description
A01	Switching on the equipment	Switching on the batteries, placing the equipment into operation
A02	Timer	CLK (ZJ1) indicator - blinks, 1Hz
A03	D1 self-diagnostics	MEM (ZJ2) indicator – lit
A04	D2 self-diagnostics	WD (ZJ3) indicator – lit
A05	SPI communication	SPI (ZJ5) indicator – lit
A06	Communication with ST1	ST1 (ZJ6) indicator – lit
A07	Communication with ST2	ST2 (ZJ6) indicator – lit
B01	D1	D1 self-diagnostics
B02	POS mode	Switch equipment to ŽSR shift mode
B03	PRE mode	Switch equipment to ŽSR operating mode
B04	VYL mode	Switch the equipment to ŽSR outage mode

Step	Tested	Description
B05	ZAV mode	Switch equipment to ŽSR tow mode
B06	Max = 40 km/h	Set maximum train speed to 40 km/h
B07	Max = design speed	Set maximum train speed to design speed
B08	TOL mode	Switch equipment to MÁV shift mode
B09	MEN mode	Switch equipment to MÁV operating mode
B10	TEST	Switch equipment to TEST mode
C01	Indicator NO5	ENTER button => blue light lit
C02	Indicator NO4	ENTER button => hollow ring light lit
C03	Indicator NO3	ENTER button => green light lit
C04	Indicator NO2	ENTER button => red light lit
C05	Indicator NO1	ENTER button => yellow light lit
C06	Indicators NO7 to NO10	ENTER button => 4 LED indicators lit
C07	Left segment NO11	ENTER button => left display segment lit
C08	Center segment NO11	ENTER button => centre display segment lit
C09	Right segment NO11	ENTER button => right display segment lit
C10	Minimal light	Shading of light sensor
C11	Maximum light	Illumination of light sensor with a source of light
C12	EPV - Channel M	ENTER button => opens EPV
C13	EPV - Channel C	ENTER button => opens EPV
C14	Blue registration	ENTER button => closes contact for blue aspect registration
C15	Red registration	ENTER button => closes contact for red aspect registration
C16	Horn 1	ENTER button => switches on horn at cab 1
C17	Horn 2	ENTER button => switches on horn at cab 2
C18	OZB output	User output check (always closure control)
C19	OD1 output	User output check (D1 performance indicator)
C20	Remote shutdown	Simulation on remote shutdown contact
C21	Driving controllers a	Manipulation of driving controller
C22	Vigilance button 1	Pressing the vigilance button at cab 1
C23	Vigilance button 2	Pressing the vigilance button at cab 2
C24	Direction controller 1	Direction controller, 1st signal
C25	Direction controller 2	Direction controller, 2nd signal
C26	System switch	System switch in SS position
C27	Auxiliary brake	Engage and release the auxiliary brake
C28	Green aspect	MIREL VZT tester => 5,4 Hz / 50 Hz / 2 A
C29	Green aspect	MIREL VZT tester => 5,4 Hz / 50 Hz / 8 A
C30	Green aspect	MIREL VZT tester => 5,4 Hz / 50 Hz / 20 A
C31	Green aspect	MIREL VZT tester => 5,4 Hz / 75 Hz / 2 A
C32	Green aspect	MIREL VZT tester => 5,4 Hz / 75 Hz / 8 A
C33	Green aspect	MIREL VZT tester => 5,4 Hz / 75 Hz / 16 A
C34	Yellow aspect	MIREL VZT tester => 3,6 Hz / 50 Hz / 2 A
C35	Yellow aspect	MIREL VZT tester => 3,6 Hz / 50 Hz / 8 A
C36	Yellow aspect	MIREL VZT tester => 3,6 Hz / 50 Hz / 20 A
C37	Yellow aspect	MIREL VZT tester => 3,6 Hz / 75 Hz / 2 A
C38	Yellow aspect	MIREL VZT tester => 3,6 Hz / 75 Hz / 8 A
C39	Yellow aspect	MIREL VZT tester => 3,6 Hz / 75 Hz / 16 A
C40	Hollow ring	MIREL VZT tester => 1,8 Hz / 50 Hz / 2 A
C41	Hollow ring	MIREL VZT tester => 1,8 Hz / 50 Hz / 8 A
C42	Hollow ring	MIREL VZT tester => 1,8 Hz / 50 Hz / 20 A
C43	Hollow ring	MIREL VZT tester => 1,8 Hz / 75 Hz / 2 A
C44	Hollow ring	MIREL VZT tester => 1,8 Hz / 75 Hz / 8 A
C45	Hollow ring	MIREL VZT tester => 1,8 Hz / 75 Hz / 16 A
C46	Red aspect	MIREL VZT tester => 0,9 Hz / 50 Hz / 2 A

Step	Tested	Description
C47	Red aspect	MIREL VZT tester => 0,9 Hz / 50 Hz / 8 A
C48	Red aspect	MIREL VZT tester => 0,9 Hz / 50 Hz / 20 A
C49	Red aspect	MIREL VZT tester => 0,9 Hz / 75 Hz / 2 A
C50	Red aspect	MIREL VZT tester => 0,9 Hz / 75 Hz / 8 A
C51	Red aspect	MIREL VZT tester => 0,9 Hz / 75 Hz / 16 A
C52	Speed order 1	MIREL VZT tester => telegram 1 MÁV / 1,5 A
C53	Speed order 1	MIREL VZT tester => telegram 1 MÁV / 8 A
C54	Speed order 1	MIREL VZT tester => telegram 1 MÁV / 16 A
C55	Speed order 2	MIREL VZT tester => telegram 2 MÁV / 1,5 A
C56	Speed order 2	MIREL VZT tester => telegram 2 MÁV / 8 A
C57	Speed order 2	MIREL VZT tester => telegram 2 MÁV / 16 A
C58	Speed order 3	MIREL VZT tester => telegram 3 MÁV / 1,5 A
C59	Speed order 3	MIREL VZT tester => telegram 3 MÁV / 8 A
C60	Speed order 3	MIREL VZT tester => telegram 3 MÁV / 16 A
C61	Speed order 4	MIREL VZT tester => telegram 4 MÁV / 1,5 A
C62	Speed order 4	MIREL VZT tester => telegram 4 MÁV / 8 A
C63	Speed order 4	MIREL VZT tester => telegram 4 MÁV / 16 A
B11	Speed order 0	MIREL VZT tester => carrying frequency off
B12	v = 10 km/h	MIREL VZT tester => speed of 10 km/h
B13	v = 40 km/h [1]	MIREL VZT tester => set speed to 40 km/h
B14	v = 120 km/h	MIREL VZT tester => set speed to 120 km/h
B15	v = design speed	MIREL VZT tester => set speed to maximum design speed
B16	p = 1 bar	Set pressure in main line => pressure of 1 bar
B17	p = 3 bar	Set pressure in main line => pressure of 3 bar
B18	p = 5 bar	Set pressure in main line => pressure of 5 bar

Test Report:

A test report for a functional test must include the following details:

- Date and time
- Site of performance
- Serial numbers of all train protection system components
- Number of the locomotive on which the equipment is installed (if such a number exists)
- Name and position of the technician who completed the test
- Result of the functional test (no faults or with faults)
- If faults are discovered, their description must be provided
- Signature of the technician member who completed the test

Resolving Discovered Faults:

Operating repairs (S1) must be performed if a fault is detected in the equipment. Maintenance repairs (S2) are needed if a fault repeatedly appears.

D4 – Preventative Inspection

Performed by:

Trained manufacturer employee

Deadline:

Regularly, once every 24 months with a tolerance of ± 2 months.

If the MIREL VZ1 train protection system is out of service for more than 12 months, a full scale D4 preventative inspection must be performed before it is placed back into service. The term "out of service" means that the train protection section (or its components) is not installed on any locomotive or is installed but not regularly connected to a power source.

If a preventative inspection is performed in the defined tolerance, the date for the next preventative inspection is defined as the date of the prior inspection + 24 months.

Description:

A preventative inspection is subject to a specific internal procedure of the manufacturer for in-depth equipment inspection. The methodology for performing the D4 preventative inspection depends on the installation of the MIREL VZ1 train protection system on individual classes of rail vehicles. Any changes that result from future installations that will have an impact on the scope and performance of a D4 preventative inspection will be incorporated into the methodology procedure for performing D4 preventative inspections.

A preventative inspection is only considered complete if the entire test procedure has been completed.

Test Report:

A test report for a preventative inspection must contain the following details:

- Date and time
- Site of performance
- Train protection system serial number
- Number of the locomotive on which the equipment is installed
- Name and position of the technician who completed the task
- Results of the preventative inspection
- If faults are discovered, their description must be provided
- Signature of the technician who completed the test

Resolving Discovered Faults:

Operating repairs (S1) must be performed if a fault is detected in the equipment. Maintenance repairs (S2) are needed if a fault repeatedly appears.

Equipment Maintenance

All train protection system components are maintenance free. No component requires any periodic replacement, calibration or adjustment.

Maintenance of the MIREL VZ1 Train Protection System is Dual Level

S1	Operating Repairs
S2	Maintenance Repairs

Operating repairs (S1) are performed by the operator's trained technicians. An inspection is performed if faults are discovered during any diagnostic inspection (D1 to D4) or if faults are experienced in the operation of the train protection system. Operating repairs seek to eliminate the root cause of a fault in cabling, power or connections to accessory equipment on the locomotive. No interference into the inside of a central processor unit or signal repeater takes placed during a maintenance inspection. Maintenance repairs (S2) are needed if a fault repeatedly appears.

Maintenance repairs (S2) are performed by the manufacturer or other entities trained and authorized by the manufacturer. Maintenance repairs are performed to eliminate the root cause of a fault discovered during operating repairs (S1) if possible. Maintenance repairs always involve replacement (replacement of the central processor unit or signal repeater with subsequent manufacturer repairs). Maintenance repairs are intended to eliminate the root causes of faults in the train protection system's central processor unit and signal repeaters.

Every technician performing maintenance repairs on a train protection system must be instructed with respect to occupational health regulations, must be verifiably trained to perform these activities and must have verifiable authorization to perform the individual levels of equipment maintenance activities.

S1 - Operating Repairs

Performed by:

Technician trained by the train protection system's operator

Deadline:

If faults in the train protection system are discovered during diagnostic checks (D1 to D4) or during operations of the train protection system

Description:

The goal of operating repairs is to eliminated faults in:

- Power for the central processor unit
- Power for the signal repeaters
- Cabling
- Connection to axle revolution sensor
- Connection to main line pressure sensor
- Code sensor connections
- Communication connectors
- I/O circuit connections
- Vigilance button connections
- Mechanical anchoring

The portions of the D3 functional test that may help specify the given fault should be performed before S1 operational repairs. If a fault occurs in the train protection system's central processor unit or signal repeater, repairs consist of replacing the given components. The technician completing operating repairs must have approved technical documentation available for the equipment and is obliged to follow the provisions in technical documentation and this maintenance manual.

If S1 operational repairs do not eliminate all of the faults that have occurred, S2 maintenance repairs on the train protection system are required. If S1 operational repairs do eliminate all of the faults that have occurred, a functional test of the equipment must be performed.

Test Report:

The test report for a maintenance inspection must include the following details:

- Date and time
- Site of performance
- Site of performance
- Number of the locomotive on which the equipment is installed
- Name and position of the technician who performed the maintenance inspection
- Description of the faults that were resolved and their root causes (if known)
- Description of faults that could not be resolved by the maintenance inspection
- Serial numbers of all removed and installed components
- Signature of the technician who performed the repairs

S2 – Maintenance Repairs

Performed by:

Trained manufacturer employee

Deadline:

If faults in the train protection system are found and cannot be eliminated by operating repairs

Description:

A maintenance inspection is to eliminate faults that have occurred in:

- The central processor unit of the train protection system
- The signal repeaters
- Train protection system interaction with peripherals and other locomotive components that could not be resolved by an S1 maintenance inspection

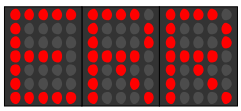
A D3 functional test must be performed and a test report must be completed after finishing maintenance repairs.

Test Report:

The test report for maintenance repairs must contain the following details:

- Date and time
- Site of performance
- Train protection system serial number
- Number of the locomotive on which the equipment is installed (if so installed)
- Name and position of the technician who performed the maintenance repairs
- Description of the faults that were resolved and their root causes (if known)
- Serial numbers of all removed and installed components if replacements were made
- Signature of the technician who performed the repairs

Fault Signalization



Faults in the train protection system are divided into two groups. Faults that prevent operation of the train protection system and faults that limit operation of the train protection system. If a fault that prevent operations occurs, the equipment will automatically switch into safe mode, opening the EPV emergency brake value and the ERR (ZJ8) indicator will light on the front panel of the central processor unit. Switching the train protection system's breaker off for at least 1 second after any failure and then switching on the breaker will reinitialize the train protection system. The operator should not perform any other actions if the same fault indicator is shown.

Special attention must be given during re-initialization to ensure the equipment uses the pre-selected parameters. The numbered code of the equipment fault will be displayed in order to assist in troubleshooting the fault by pressing the CONFIRM (NO14) button on the signal repeater.

Faults preventing operation of the train protection system:

E00	Permanent communication loss between signal repeater and central processor unit
E01	Fault in supervisory loops (watchdog) of the central processor unit
E02	EEPROM fault in central processor unit
E03	Comprehensive fault in signal repeater ▪ Fault in signal repeater supervisory loop ▪ Fault in signal repeater memory ▪ Signal repeater communication fault ▪ Integrity fault in pre-set parameters in the signal repeater
E04	Communication fault between central processor unit and signal repeater in 1st cab
E05	Communication fault between central processor unit and signal repeater in 2nd cab
E06	Processor module communication fault in central processor unit
E07	Fault in code sensor transmission during non-continuous self-diagnostics
E08	EPV fault during non-continuous self-diagnostics
E09	Fault from failure to perform D1 self-diagnostic test within 4 hours from switching the equipment on
E10	Activation integrity fault in central processor unit's processor modules
E11	EPV fault during activation of train protection system - insufficient pressure drop
E12	Locomotive movement with insufficient main brake line pressure
E14	Fault in maximum permitted speed assessment integrity
E15	Fault in signal code assessment integrity pursuant to ŽSR specifications or speed order assessment pursuant to MÁV specifications
E20	Speed measurement fault
E21	Fault in assessment of actual direction of travel
E22	Power fault for incremental revolution sensor
E23	Power fault for main line pressure sensor
E24	Main line pressure measurement fault
E25	Speed measurement integrity fault between channels M and C
E26	Main line pressure measurement integrity fault between channels M and C

E27	Fault in work mode assessment integrity between channels M and C
E28	Fault in signal repeater data integrity between channels M and C
E30	Fault in processor decoding and execution of instructions
E31	Integrity fault in pre-set operating parameters
E32	Fault in repeated execution of D1 self-diagnostics
E33	Fault in integrity of train protection system configuration data
E40	Central processor unit FLASH memory fault
E41	Central processor unit RAM memory fault
E42	Integrity fault in UNI section of software
E43	Fault in software integrity – ŽSR section
E44	Fault in software integrity – MÁV section
E50	Comprehensive fault in signal repeater control module
E51	Fault in communication with signal repeater control module
E52	Integrity fault in signal aspect indicated on the signal repeater

A fault that limits operation of the train protection system does not open the EPV emergency brake valve. No fault is indicated on the front panel of the central processor unit or on the signal repeater in the active cab. Such a fault involves the signal repeater in the inactive cab. These faults limit operation of the train protection system to the signal repeater located in the trouble-free cab.

Any faults detected in the ZAV operating mode of travel are classified as faults that limit operations. These faults are reclassified into faults that prevent further operation after the locomotive has come to a stop. In practice this means that the EPV opens due to a fault detected once the locomotive comes to a stop.

Faults limiting operation of the train protection system indicated on the signal repeater in the inactive cab:

E00	Comprehensive signal repeater fault ▪ Signal repeater supervisory loop fault ▪ Signal repeater memory fault ▪ Permanent comm. loss between signal repeater and central processor unit ▪ Signal repeater communication fault ▪ Integrity fault in pre-set parameters in the signal repeater

Adjusting for Wheel Diameter

The wheel diameter adjustment for the locomotive axle sensor is performed using a portable diagnostics computer. The computer is connected to the train protection system's central processor unit using the SAI connector on the rear panel or using a connected MIREL RM1 registration speedometer. The MIREL KAM program is then run on the diagnostics computer. Communication between the diagnostics computer and the train protection system is indicated on the computer's display and by the ZJ5 indicator on the front panel of the central processor unit. The operator must follow the user manual for the MIREL KAM software package when making the actual adjustment.

The periodicity of adjusting the wheel diameter for the monitored axle must be defined by the operator in a specific regulation.

Installation and Removal of Equipment

Installation and Removal of the Central Processor Unit

The central processor unit is secured using 4 M6 screws along the edges of the front panel. A 72-pin industrial DD connector with two safety catches and a DB connector are located on the rear. The locomotive's battery power must be switched off or the train protection system's breaker must be switched off during installation and removal. The installation procedure follows:

- Attachment of the 72-pin DD connector
- Closure of the connector's safety catches
- Attachment of the DB connector
- Positioning into installation site
- Installation and tightening of fastener screws

Removal is performed using the reverse of this procedure.

Installation and Removal of Signal Repeater in Aluminium Box

The signal repeater is secured to hinges, which are themselves secured using 4 M4 screws to the train driver's dashboard. Cabling exits the box from the lower side and is connected to the terminal strip in the driver's dashboard. The locomotive's battery power must be switched off or the train protection system's breaker must be switched off during installation and removal. The installation procedure follows:

- Connection to terminal strip in the driver's dashboard
- Positioning into installation site
- Installation and tightening of fastener screws

Removal is performed using the reverse of this procedure.

Installation and Removal of the Dashboard-Version Signal Repeater

This type of signal repeater is inserted into a cover piece in the locomotive's dashboard and anchored using a part of anchors. The back of the equipment houses a terminal strip for connecting electrical cabling. The locomotive's battery power must be switched off or the train protection system's breaker must be switched off during installation and removal. The installation procedure follows:

- Insert the equipment into the cover piece
- Position the anchors
- Connect cabling to the equipment's terminal strip
- Position the cover piece into the desired position
- Secure the cover piece to the dashboard (depends on the type of locomotive)

Removal is performed using the reverse of this procedure.

Installation and Removal of Horn in a Separate Box

The horn is secured to hinges, which themselves are secured using 2 M4 screws. The terminal strip is located on the rear of the box. The locomotive's battery power must be switched off or the train protection system's breaker must be switched off during installation and removal. The installation procedure follows:

- Connect the terminal strip on the rear of the box
- Positioning into installation site
- Installation and tightening of fastener screws

Removal is performed using the reverse of this procedure.

Installation and Removal of Dashboard-Version Horn

The procedure is the same as for the dashboard-version signal repeater.

Notes