No:

153VZ1

Version:

230726

System / Product:

Train Protection System MIREL VZ1

v04

Title:

Operating manual

Further source and enclosed files:

	File	Description	Pages / Connection
1			
2			
3			

The document form is based on template 2738M:201210

List of document versions:

Version	Description	Compiled by	Validated by	Approved by
000515	Document implementation			Horváth
001011	Supplement No. 1			Horváth
040511	Supplement No. 2, SW v02			Horváth
060117	Rework, addition of EVM functionalities			Horváth
061102	Changes after EVM functional tests, SW v03			Horváth
070321	Changes after LS, EVM functional tests, SW v03			Horváth
071210	Changes arising from LS trial operation			Horváth
080128	Changes after termination of EVM trial operation			Horváth
090110	Changes after termination of ŽSR, ČD trial operation. Extension of EVM functional properties to 160 $km.h^{-1}$			Horváth
090822	Modifications prior to v03 approval			Horváth
100714	Addition of SHP functionality			Horváth
110628	SHP functionality modification – remarks from operation			Horváth
110828	System version v04			Horváth
141119	Changes integrated from trial operation			Horváth
190111	Document update and maintenance	Praščák	Horváth	Horváth

Version	Description	Compiled by	Validated by	Approved by
201120	Addition and modification of error codes for MIREL STB and MIREL SHPE	Grman	Michalec	Michalec
221118	Modification of error codes for gateway MIREL STB	Grman	Michalec	Michalec
221227	Modification of description of SHP operating mode functionality in connection with approval	Bobek	Michalec	Michalec
230215	Splitting of system error list according to the version of the MIREL VZ1 technical conditions and SHP functions according to the version of the SHP technical description	Grman	Michalec	Michalec
230726	Modification of D1 test specification	Žilinec	Michalec	Michalec

Table of Contents

1 Purpose of the Document

Document specifies method and conditions of MIREL VZ1 train protection operation. In the actual version it describes the operation of MIREL VZ1 train protection in version v04.

Operation manual comprises principal description of system hardware, description of system national modes, description of system operating modes, description of system operating and system functions. Manual specifies standard operating procedures during use, in connection with DRV control procedures.

Train protection operating manual is a document intended primarily for DRV operating and maintenance personnel. Further, the manual has been intended as a help for implementation of training and checking activity, a help for system incorporation into DRV technology, its activation, testing and implementation of system tests.

MIREL VZ1 train protection can be operated during DRV operation only a person, which has been, apart from complying with general legislative requirements for driving rail vehicles operation, demonstrably trained for operation of a given DRV and is in possession of authorization for execution of such activity from operator´s responsible representative. Qualification requirements of operating staff aren´t stipulated in present document and they aren´t laid down by train protection system Producer.

Compliance with qualification requirements of production, assembly, maintenance and diagnostic staff of MIREL VZ1 train protection is achieved by their specialist professional education and a demonstrable training for mentioned activity, which is periodically renewed. Specifications of MIREL VZ1 train protection maintenance terms and conditions have been listed in document Train Protection Operating Manual, Diagnostics (Document No: 154VZ1) and in System Technical Conditions (Document No: 257VZ1).

MIREL VZ1 train protection Operating Manual complements the overall DRV operating manual of a given series and is applicable solely in interaction with it. MIREL VZ1 train protection Operating Manual doesn´t, under any circumstances, replace any provisions of valid legislative and operating regulations and procedures related with control of driving rail vehicles and/or railway operation control. Valid legislative and operating regulations and procedures have an absolute precedence over present Operating Manual.

Document is intended for:

- DRV operator staff carrying out operating and maintenance activities on MIREL VZ1 system
- System Producer staff trained and authorized to conduct MIREL VZ1 system–activities of fitting, activation, testing, tests implementation
- Staff of companies engaged in DRV production, reconstruction and maintenance, which has been trained and assigned to conduct activities of system operation, fitting, testing, diagnostics and maintenance

Document follows up and refers to documentation below:

Related Documentation

No.		Version	Title
[A1]	257VZ1	211203	Technical Conditions
[A2]	257VZ1	200401	Technical Conditions
[A3]	2038VZ1	190313	SHP technical description
[A4]	2038VZ1	151015	SHP technical description

Linked Documentation

No.		Version	Title
[B1]	154VZ1	221118	Maintenance manual, diagnostics

Cited and related standards and specifications

No.		Version	Title and Additional Information
[C1]	EUR-Lex-32014R1302	2014	COMMISSION Directive (EU) No. 1302 concerning a technical specification for interoperability relating to the “rolling stock – locomotives and passenger rolling stock” subsystem of the rail system in the EU

2 Specification of Document Changes

Version 000515

Document implementation.

Version 001011

Supplement to Operating Manual of MIREL VZ1 automatic train protection, dated 11. 10. 2000, which resulted from technical system safety requirements (additions in sections: Putting into Operation and Operation Termination, Data Entry, Error Indication).

Version 040511

Supplement to Operating Manual of MIREL VZ1 automatic train protection, dated 11. 5. 2004, which resulted from approval of Supplement No. 1 to Technical Conditions for MIREL VZ1 Automatic Train Protection - serial usage (257VZ1: 040305).

Version 060117

Supplementation of EVM functions and document update.

Version 061102

Document update upon accomplishment of EVM functions test with software version v03.

Version 070321

Document update upon accomplishment of LS and EVM functions test with software version v03

Version 071210

Functionality modification according to the LS specification and implementation of functionality according to the EVM specification dated 10.12.2007, based on Set of Functional Requirements for MÁV Rt On-Board Train Protection Systems and Vigilance Equipment (738VZ1: 060112), Specification of Changes to MIREL VZ1 Automatic Train Protection System – Integration of MÁV Rt functionalities (412VZ1: 071203) and Supplement No. 2 to Technical Conditions of MIREL VZ1 Automatic Train Protection Serial Service (257VZ1: 070525).

Version 080128

Document update upon accomplishment of test operation on EVM infrastructure.

Version 090110

Functionality modification according to LS specification after accomplishment of v03 software test in trial operation and extension of functionality according to EVM specification to 160 $km.h^{-1}$ based on Set of Functional Requirements for MÁV Rt On-Board Train Protection Systems and Vigilance Equipment (738VZ1: 081020).

Version 090822

Document update prior approval of train protection in version v03.

Version 100714

Supplementation of functionality pursuant SHP specification, based on SHP specification and technical description (1054VZ1 : 120910), including incorporation of operating remarks.

Version 110628

Document update in extent of SHP function properties, based on remarks from operation.

Version 110828

Document update in connection with transfer to system version v04.

Supplementing and adjustment of MIREL VZ1 train protection Operating Manual in accordance with system technical conditions (257VZ1 : 110610). Supplementing standby mode functionality and interaction with ETCS-type train protection.

Version 141119

Document update in extent of changes resulting from verification operation of version v04.

Version 190111

Update and adjustment of MIREL VZ1 train protection Operating Manual in accordance with system technical conditions (257VZ1 : 190121).

Version 201120

Update and supplementation of error codes for MIREL STB and MIREL SHPE.

Version 2221118

Error code updates for MIREL STB.

Update of indication elements on train protection central unit in connection with approval process of INO2019 changes.

Document form update to actual technical documentation template.

Version 221227

Updating, supplementing and clarification of SHP functions.

- Changed description of the CA and SHP visual indication.
- Changed description of behaviour when pressing TB permanently in SHP operating mode.
- Changed designation of audible signalling in SHP operating mode.

Version 230215

Splitting of diagnosed system errors list according to the version of the MIREL VZ1 technical conditions (257VZ1 : 211203 and 257VZ1 : 200401).

Marked differences of SHP functions according to the version of the technical description of SHP functions integration (2038VZ1 : 190313 and 2038VZ1 : 151015).

Addition of the standby operating mode indication on the signal repeater display.

Version 230726

Addition of the D1 interval specification also for systems after useful life in chapter 8.

Addition of Chapter 21 *TSI Operational Functionalities* and Chapter 22 *TSI System Intervention*.

3 Applied Designation and Terminology

Active driver cab	Engine driver cab on a rail vehicle with control switch engaged
EVM	Train protection function specification for operation in Hungary
DRV	Driving rail vehicle
HP	MIREL VZ1 train protection horn
LS	Train protection function specification for operation in Slovak and Czech Republics
Maximum design speed	Maximum speed specified by rail vehicle producer, or speed laid down as a maximum one upon a reconstruction
Maximum operating mode speed	Maximum speed laid down for actually active train protection operating mode
Maximum speed derived from transmitted signals, target speed	Rail vehicle maximum speed, allowed for ride at rail line section end with respective signal indication
NO	Signal repeater of MIREL VZ1 train protection
Self-acting halt, emergency halt, train protection intervention	Automatic rail vehicle halt upon train protection intervention by means of directly-acting brake EPV valve opening due to violation of any safety condition
SHP	Functional specification of the train protection system for operation in the Republic of Poland
SHPE	MIREL SHPE evaluating and checking unit intended to protect a rail vehicle on Polish rail line infrastructure
Specified speed	Speed as laid down by applicable regulations for train set and rail line conditions as a maximum one (usually stipulated in timetable notebook)
STB	Train protection function specification for STM module operation in standby mode
MIREL STB	MIREL STB function port providing interface between central unit of MIREL VZ1 train protection and ETCS on-board unit
Rail line part of train protection	Stationary part of line-type train protection, operating with a carrier frequency of 50 Hz or 75 Hz, stationary part of point-type train protection of SHP type
VZ, train protection	MIREL VZ1 train protection
ZJ	Central unit of MIREL VZ1 train protection

4 General Characteristics

The MIREL VZ1 automatic train protection system is the mobile part of train protection system. It is intended for operation on rail vehicles operated on the territory of Czech Republic, Slovakia, Hungary and Poland. The system is compatible with LS-, EVM- and SHP-type rail line infrastructure. The system cooperates with on-board train protections of ETCS-type. MIREL VZ1 is an open system, which can be supplemented in the future with another system for transmitting route information to the vehicle.

The MIREL VZ1 train protection is intended to supervise train driver´s vigilance, information transmission from rail line infrastructure to driver´s cab, the maximum speed supervision with regard to the maximum rail vehicle design speed, pre-set speed and information received from rail line infrastructure. By means of additional functions, the system supervises the accord of preselected and actual travel direction, evaluates commands of remote rail vehicle stopping via radio station and checks the braking of a rail vehicle at standstill.

The complete set of MIREL VZ1 train protection consists of central unit, pair of signal repeaters housed at driver´s cab as well as a pair of signalling horns. The interconnection of central unit with signal repeaters is achieved by means of a communication line with serial data transmission. Alternatively, operation only with a single signal repeater is possible, depending on required system configuration. MIREL VZ1 can be operated on single- as well as twin-driver´s cab rail vehicles. The system can be configured for rail vehicles which must provide information transfer from rail line infrastructure to driver´s cab, as well as for vehicles operated on lines without train protection line infrastructure. The MIREL VZ1 train protection can be operated on driving rail vehicles (DRV) of electric traction, diesel traction as well as on driving cars.

MIREL VZ1 train protection device is powered from the rail vehicle batteries. The MIREL VZ1 system configuration is based on the voltage supplied by these batteries. Train protection operation and control is carried out exclusively from driver´s cab, by means of signal repeater and control elements, like vigilance pushbuttons and other control elements installed on the driver's dash. When operating the MIREL VZ1 train protection device, no other intervention in the rail vehicle engine room is required.

The MIREL VZ1 train protection device is a digital electronic system designed as a fail-safe equipment. Fail-safe operation is ensured by a duplex processor unit, a group of special supervisory circuits, double-channel information transfer from rail line infrastructure, double-channel measurement of travel speed, travelled distance and of travel direction. Signal repeaters are composed of redundant, single-purpose, single-board computers, which have been designed especially for this purpose. The employed set of parts meets the most demanding criteria for reliability and endurance.

The MIREL VZ1 train protection performs one-time as well as continuous diagnostics and enables to perform functional test for correct functioning check-up of all MIREL VZ1 train protection elements and cooperating functional units. Besides the execution of functional test and prophylactic inspection, the system is maintenance-free.

5 System Composition

Complete system Composition:

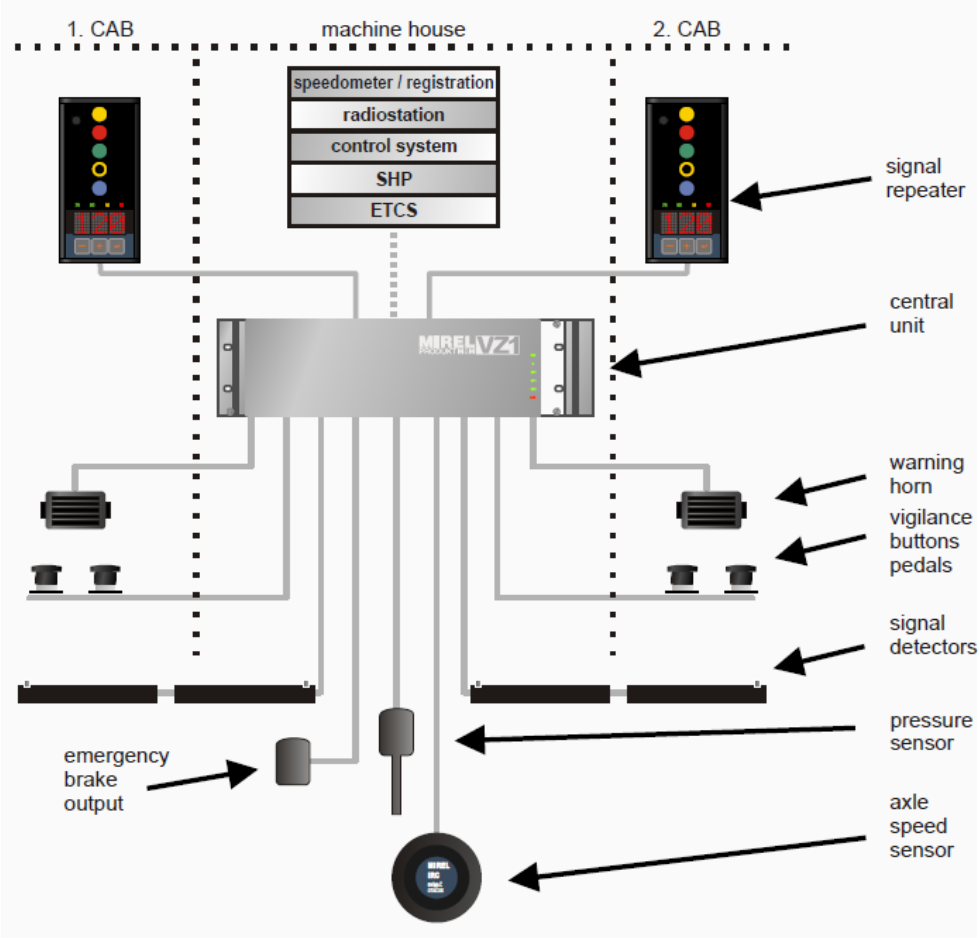
- central unit 1x
- signal repeater 2x
- horn 2x

Obligatory Cooperating Functional Units:

- vigilance pushbuttons and pedals number and type dependent on DRV type
- incremental axle speed sensor 1x
- sensor of pressure in main brake line 1x
- registration unit 1x

Obligatory cooperating functional units:

- sensors of signal from line infrastructure alternatively: 4x, 2x, 0x
- speedometer dependent on DRV type
- control system or ARR dependent on DRV type
- radio station dependent on DRV type
- SHP system dependent on DRV type
- ETCS system dependent on DRV type



Note: Scheme of set of units is illustrative. Components of system set of units can have various structural design versions.

6 Central Unit

Central unit of the system provides the majority of MIREL VZ1 train protection system operating functionalities.

- filtration and decoding of information transferred from railway line infrastructure part
- filtration and evaluation of signal from vehicle pulse axle speed detector
- (measurement of travel speed, travelled distance and evaluation of travel direction)
- safety algorithm computation
- pressure sensing in the main brake line
- input sensing (cabin switches, vigilance buttons and pedals, drive controllers, automatic brake actuator, direction controllers, traction system switch...)
- output preparation (control of EPV valve, horn, blue and red light indication...)
- communication with signal repeaters
- system diagnostics
- functional test of the system
- indication

There are 8 indication LED´s located on central unit front panel. There aren´t any control elements on the central unit and any interventions required on system´s central unit when operating the train protection system.

The central unit is powered from battery source of the driving rail vehicle. The power supply is protected by train protection system circuit breaker located within the set of other DRV circuit breakers or at specific location, dependent on driving rail vehicle type. There isn´t any operating situation with necessity to switch off the power supply circuit breaker of the system. Other components of MIREL VZ1 train protection are powered via central unit.

Structural design of central unit in version BOX3U complies with its width measures with standard IEC 60297, i.e. the basic width is 19”. The height dimension has been designed in the U = 44,50 mm module. Central unit modules are accommodated in an Al-box. Indication elements are located on the front panel. A 72-pin industrial connector of DD-type is placed on the rear panel.

Structural design of central unit in version BOXTUG has its modules of central unit located in a separate AL-box and is available in two different modifications, depending on assembly orientation. Indication elements are located at front panel, as well as a 37-pin connector of DB type, 25--pin connector of DB type, 15--pin connector of DB type and two 10-pin industrial connectors of type Hummel M16.

Structural design of central unit in BOXKOG has central unit modules located in a separate AL-box of modular BOXKOG-type structural system, for easy device fitting in standard 19” cases with height 3U. Indication elements are located at front panel, as well as a 37-pin connector of DB type, 25--pin connector of DB type, 15--pin connector of DB type and two 10-pin industrial connectors of type Hummel M16.

The central unit operating position is arbitrary. Positioning is within the driving rail vehicle, depending on DRV type. Under normal operating conditions and during service actions it is necessary to provide for access to the central unit front panel without the necessity to dismantle it.

Indication elements located on central unit front panel

illustrative pictures

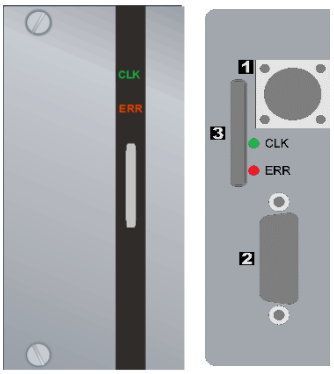
CLK	ZJ1	operation indication
MEM	ZJ2	indication of D1 diagnostics
WD	ZJ3	indication of D2 diagnostics
K	ZJ4	indication of information transfer from rail line part
SPI	ZJ5	indication of communication via SPI bus-bar
ST1	ZJ6	indication of communication with 1st driver´s cab
ST2	ZJ7	indication of communication with 2nd driver´s cab
ERR	ZJ8	system error

indication elements on VZ1ZJ.0 VZ1ZJ.1

Full indicator designation is OIZJ1 through OIZJ8. For purposes of Operating Manual clarity, we shall use abbreviated designations ZJ1 through ZJ8.

Indication elements of recording unit of central unit

illustrative pictures



CLK	ZJ9	activity indication of recording unit
ERR	ZJ10	error of recording unit

indication elements on VZ1ZJ.0 VZ1ZJ.1

Full indicator designation is OIZJ9 through OIZJ10. For purposes of Operating Manual clarity, we shall use abbreviated designations ZJ9 through ZJ10.

7 Signal Repeater

The signal repeater displays information transmitted from rail line part to driver´s cab, signals the detected signal carrier frequency in the rail line part of automatic train protection, signalization of actions implemented by train protection, maximum speed indication. It serves as well for setting of train protection operating parameters by attendants.

The signal repeater is connected to central unit by means of a 4-conductor cable, which serves for signal repeater powering and for data communication between central unit and signal repeater.

The signal repeater design execution has been arranged into AL-box or as a panel-built unit. Front panel features 4 signal indicators, blue light, 4 indication LED´s, triple-character alphanumeric display and three control buttons. In case of AL-box version, a floating cable in-feed is located on the bottom side and the signal repeater is fastened in turning joints, adjustable in angles from -30° to +210°. In case of option as a panel-built instrument, the cable in-feed is provided at rear side. Signal repeater operating position is vertical.

The active driver´s cab of train protection is the one driver´s cab, where the cabin switch is in switched-on condition.

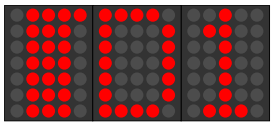
Indication and control elements located on signal repeater front panel

illustrative picture

	NO1	▪ yellow railway signal in the PRE operating mode ▪ indication of required pressure reduction in brake line in the MEN operating mode
	NO2	red railway signal
	NO3	green railway signal
	NO4	▪ annulus railway signal in the PRE operating mode ▪ increased speed mode indication in the MEN operating mode
	NO5	vigilance supervision indication
	NO6	illumination intensity sensor
75	NO7	indication of 75 Hz carrier frequency
50	NO8	indication of 50 Hz carrier frequency
M	NO9	indication MANUAL / MÁV
	NO10	▪ maximum speed decrease indication ▪ standstill indication
	NO11	triple-character alphanumeric display
	NO12	MINUS button
	NO13	PLUS button
	NO14	CONFIRMATION button

Full indicator designation is OI1NO1 through OI1NO14 and OI2NO1 through OI2NO14. For purposes of Operating Manual clarity, we shall use abbreviated designations NO1 through NO14. Signal repeater distinction results from context.

8 Putting into Operation and Termination of Operation



The MIREL VZ1 automatic train protection system is put into operation by switching the rail vehicle battery source to ON position. No other actions are required for putting into operation. After switching on, the train protection performs a one-time D1 diagnostic test, indicated in signal repeater.

After switching on, the train protection system functionality is indicated as follows:

- the **CLK** indicator (ZJ1) is flashing with a 1 Hz frequency,
- the **MEM** indicator (ZJ2) is lit permanently,
- the **WD** indicator (ZJ3) is lit permanently,
- on NO11 display, **D1** is displayed, as well as progress indication at performing of individual steps of D1diagnostic test,
- audible indicator signals the system start up by means of a quadruple brief ZS11 audible signal

After switching on, the system performs a one-time D1 diagnostic test, within which it diagnoses the communication functionality inside of the central unit, communication functionality between central unit and signal repeaters, performs diagnostics of signal transfer circuits from rail line infrastructure to on-board panel part, functionality of control elements at driver´s cab and performs diagnostics of emergency brake EPV functionality.

The one-time D1 diagnostic test is performed after each putting of system into operation and every 24 hours in continuous system operation (daily test). For systems after the useful life, the interval is shortened to 8 hours. A repeated start of D1 diagnostic test is carried out automatically, without any staff intervention. Repeated start occurs after fulfilment of following conditions:

- at first DRV stoppage after 24 hours, or 8 hours for the systems after useful life, period expiry from last D1 diagnostic test, the test is started again
- in case, when the DRV doesn´t achieve zero speed in time interval from 24 to 28 hours, or 8 to 12 hours for the systems after useful life, from last D1 diagnostic test, repeated start of D1 test isn´t enabled and system detects an error
- in case, when system operates in accordance with EVM specification, within MEN operation mode and transfers speed command 0, then the repeated start of one-time D1 diagnostic test is disabled until transfer of a different speed command
- 15 seconds before repeated start of D1 diagnostic test, the staff is notified about this fact by means of a flashing **D1** indication on signal repeater and by ZS10 audible indication. During this time period, the staff has the option to postpone the repeated start of D1 diagnostic test by pushing the button for another 15 minutes. If the button is not operated within the notification period, the D1 diagnostic test is started automatically and the only further proceeding is its execution.

A part of D1 diagnostic test is the check of signal transfer circuits from rail line infrastructure to on-board part of the train protection system. When performing this part of D1 test, the transfer of information from rail line infrastructure isn´t active, although the system is already in operating mode. The check-up time of circuits serving for signal transfer from rail line infrastructure is approx. 90 seconds from D1 test start.

A part of D1 diagnostic test is the functionality check of EPV emergency brake valve. The system activates twice the opening of emergency brake EPV, which manifests itself by a double brief pressure reduction in the main brake line. A precondition for the execution of emergency brake EPV functionality check is accomplished test of cabin switch, switched-on cabin switch at active driver´s cab, released automatic pneumatic DRV brake and the system shall not be switched in standby mode.

The one-time D1 diagnostic test includes diagnostics of input signals from control elements in driver´s cab. The staff is notified about the duty to a forced manoeuvre with control elements by a quadruple brief audible signal and **D1** indication on both signal repeaters. Should staff fail to perform the prescribed manoeuvre, the train protection system can´t be put into operating mode at any of driver´s cabs. This applies for following control elements:

- cabin switch at driver´s cab*
- travel direction lever or a different direction selector
- input from pressure switch of direct-acting brake

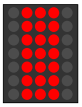
Within each D1 test, the staff at active driver´s cab has the duty to carry out following manoeuvre with control elements:

- bring the cabin switch into OFF position, with cabin switch at inactive driver´s cab being in switched-off condition*,
- bring the travel direction lever into neutral position,
- bring the travel direction lever into FORWARD position,
- bring the travel direction lever into REVERSE position,
- engage direct-acting brake,
- release direct-acting brake.

* in the case of a single-cab configuration of the system, it is not necessary to perform the given step

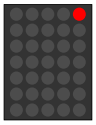
The sequence order of manoeuvres with control elements is not binding, manoeuvres with travel direction lever and direct-acting brake device must be carried out with cabin switch in switched-on condition. It is sufficient to carry out manoeuvres with control elements from the active DRV driver´s cab.

Procedure at performing individual steps of diagnostic test is indicated on signal repeater by means of a 7-segment bar in front of D1 sign. If a segment is lit, the given step hasn´t been accomplished yet. If a given segment goes out, the conditions of the respective step have been fulfilled. The meaning of individual segments is as follows:

	Position	Description
	1st line	signal repeater has established communication with central unit
	2nd line	both cabin switches have reached zero position
	3rd line	travel direction lever at active cab has reached zero position and 1st direction (forward or reverse, dependent on DRV type)
	4th line	travel direction lever at active cab has reached zero position and 2nd direction (reverse or forward, dependent on DRV type)
	5th line	direct-acting brake has acquired both conditions (brake engaged, brake released)
	6th line	in the first part of EPV test, the required pressure drop in main brake line has occurred by opening the valve via M-channel
	7th line	in the second part of EPV test, the required pressure drop in main brake line has occurred by opening the valve via C-channel

After execution of all the steps above, the indication of D1 test on signal repeater goes out and system switches to its operating mode.

If the pressure in the main brake line during the execution of D1 diagnostic test is higher than 3,5 bar, then any movement of DRV is prohibited. At DRV movement, system intervenes by opening emergency brake EPV and during movement of DRV audible indication is active by means of the ZS11 signal. All accomplished steps of D1 test lose their validity. After DRV comes to a stop, the audible indication is terminated and staff has to carry out the D1 test in full extent anew. The closure of emergency brake EPV is performed by system only after accomplishment of cabin switch test.



During the execution of D1 diagnostic test, the system tests the availability of MIREL STB functional gateway. Established communication with the MIREL STB gateway is indicated by a red dot in the left segment of NO11 display. If the communication with MIREL STB gateway isn´t established during the D1 test, system doesn´t establish the communication with MIREL STB gateway anymore during further operation and operates independently.

Should, the train protection system diagnostics detect any system error (except error of communication with signal repeater at inactive driver´s cab), the system switches to safe condition and **ERR** is displayed on displays of NO11 signal repeaters at both driver´s cabs (Section 25). The system switches itself to safe condition by activating both output channels controlling EPV. Should, after switch-on of the system, an error be repeatedly detected, staff is not allowed to bring the rail vehicle into movement. In case, that the rail

vehicle is already in operation and the system repeatedly detects an error, staff proceeds in accordance with applicable operator´s regulations for such case.

After accomplishment of D1 diagnostic test, the system switches to operating mode. Dependent on system configuration, the operating mode is activated after initial D1 test procedure in accordance with following rules.

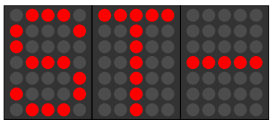
POS	Configuration has set for system POS as primary operating mode (shunting according to LS specification) for each system start.
	Configuration has set for system as primary operating mode the one, which has been active at last switch-off. Should the system be switched off in one of operating modes according to LS specification (POS, PRE, VYL, ZAV), it starts to operate in POS operating mode (shunting according to LS specification).
TOL	Configuration has set for system TOL as primary operating mode (shunting according to EVM specification) for each system start.
	Configuration has set for system as primary operating mode the one, which has been active at last switch-off. Should the system be switched off in one of operating modes according to EVM specification (TOL, MEN) it starts to operate in TOL operating mode (shunting according to MÁV specification).
SHP	Configuration has set for system SHP as primary operating mode for each system start.
	Configuration has set for system as primary operating mode the one, which has been active at last switch-off. Should the system be switched off in an operating mode in accordance with SHP specification, it starts to operate in SHP operating mode.

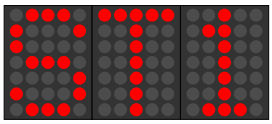
With repeated execution of D1 diagnostic test, configuration-independent, the system starts to run in the operating mode, which has been active prior to repeated execution of D1 test.

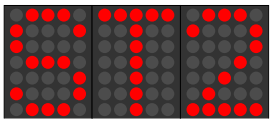
The pre-set speed is after initial execution of D1 diagnostic test set based on system configuration. After repeated execution of D1 diagnostic test, the same speed is set, like pre-set prior to repeated execution of D1 test.

The switching-off of the train protection system after termination of operation is carried out by switch-off of the drive rail vehicle´s battery source. No further actions are required to switch-off the system from operation in any operating mode.

9 Driver´s Cab Activation







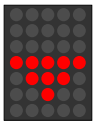
Train protection setting and operation is possible only from active driver´s cab, with cabin switch on. If none of the control switches is in the on-position, train protection system hasn´t got activated driver´s cab and both cabs are inactive. In case of simultaneous switching-on of both cabin switches, the system operates like without any cabin switch engaged.

In case of rail vehicle with a single driver´s cab, operation with permanently activated driver´s cab is possible.

Indication of an active and inactive driver´s cab is provided on display and signal repeater indicators. The indication method depends on the respective national and standby mode, in which the system is operating.

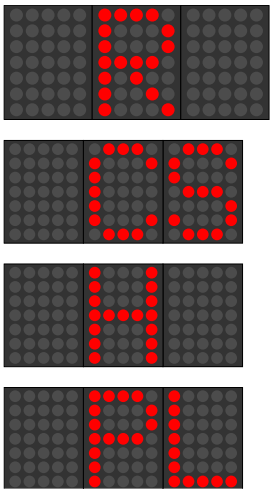
Signal repeater indication on active driver´s cab is described in subsequent Operating Manual sections, dependent on active national and operating system mode. Indication at inactive driver´s cab is regulated in accordance with following table.

Mode	Indication at inactive driver´s cab
LS	display NO11 **ST–** : none of driver´s cabs has been activated display NO11 **ST1** : system has been activated at 1st driver´s cab display NO11 **ST2** : system has been activated at 2nd driver´s cab
EVM	indicator **M** (NO9) active, display (NO11) switched-off
SHP	display NO11 **ST–** : none of driver´s cabs has been activated display NO11 **ST1** : system has been activated at 1st driver´s cab display NO11 **ST2** : system has been activated at 2nd driver´s cab
Standby mode	without indication



When switching off the control switch at driver´s cab during a system intervention or in case of system intervention with control switched-off at driver´s cab, the system intervention and subsequent opening of emergency brake EPV are indicated on NO11 signal repeater display by means of a red triangle in the right-side display segment.

10 National Modes



The MIREL VZ1 train protection operates in one of three national modes: LS, EVM and SHP. Each national mode contains a group of operating modes, which define unequivocally the operating and safety system functionalities during operation of national train protection in territory of the respective state. The extent of available national modes is given by the system configuration. Determination of national modes is as follows:

National mode	Text in menu	Range of use
LS	CS	Czechia, Slovakia
EVM	H	Hungary
SHP	PL	Poland

By means of national mode selection it is unequivocally specified, which national modes can be activated, based on which specification the system operates and which texts and signs are displayed on signal repeater. When system is operated in individual national modes, following operating modes are available:

National mode	Operating mode	Description
LS	POS	rail vehicle shunting
	PRE	operation with full functionality on LS infrastructure
	VYL	operation without transfer of information from LS infrastructure
	ZAV	rail vehicle as dead in pulling or pushing
EVM	TOL	rail vehicle shunting
	MEN	operation with full functionality on EVM infrastructure
SHP	SHP	operation with full functionality on SHP infrastructure

By way of configuration, the use of specific national modes can be permitted or prohibited.

Switching between national modes is done via menu on signal repeater (more in detail described in Section 24). After switching the system into LS national mode, the POS operating mode is pre-set. After switching the system into EVM national mode, the TOL operating mode is pre-set.

System operation in the EVM national mode is indicated on signal repeater by permanently lit **M** indicator. After first switching of system into EVM national mode, after accomplishment of D1 test an additional diagnostics of vigilance promptings is carried out in accordance with EVM specification. System displays one vigilance prompting and opens the train protection EPV. After confirmation of vigilance prompting, the EPV shall close itself.

System operation in the SHP national mode is indicated by permanently lit point in top right corner of the NO11 signal repeater alphanumeric display. After first switching of the system over to SHP national mode, after execution of D1 test, an additional diagnostic run, pursuant to SHP specification. System issues a one-time visual vigilance prompting, opens train protection EPV and waits in this condition for confirmation of prompting. Confirmation is performed by pressing the button (NO14) on the signal repeater. EPV closes after confirmation of vigilance prompting.

If the MIREL VZ1 system operates in cooperation with ETCS system, like its STM module, the national mode selection is carried out solely by ETCS system. In such case the national mode selection via signal repeater isn´t available and DRV staff has no possibility to set or change active system national mode directly on MIREL VZ1 train protection system. Operating mode selection within a given national mode is enabled.

National mode change procedure LS → EVM on signal repeater is as follows:

- 3x button , display: **R**
- 1x button , display: **CS** flashes
- 1x button , display: **H** flashes
- 1x button , display: **H** permanently lit

National mode change procedure LS → SHP on signal repeater is as follows:

- 3x button , display: **R**
- 1x button , display: **CS** flashes
- 2x button , display: **PL** flashes
- 1x button , display: **PL** permanently lit

National mode change procedure EVM → SHP on signal repeater is as follows:

- 2x button , display: **R**
- 1x button , display: **H** flashes
- 1x button , display: **PL** flashes
- 1x button , display: **PL** permanently lit

National mode change procedure EVM → LS on signal repeater is as follows:

- 2x button , display: **R**
- 1x button , display: **H** flashes
- 1x button , display: **CS** flashes
- 1x button , display: **CS** permanently lit

National mode change procedure SHP → LS on signal repeater is as follows:

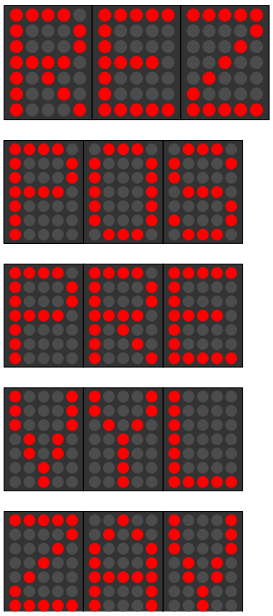
- 1x button , display: **R**
- 1x button , display: **PL** flashes
- 2x button , display: **CS** flashes
- 1x button , display: **CS** permanently lit

National mode change procedure SHP → EVM on signal repeater is as follows:

- 1x button , display: **R**
- 1x button , display: **PL** flashes
- 1x button , display: **H** flashes
- 1x button , display: **H** permanently lit

Switching between national modes can be carried out only with vehicle at standstill.

11 LS Operating Modes



The MIREL VZ1 train protection operates in LS national mode in one of following operating modes:

Operating mode	Operating mode purpose
POS	DRV shunting
PRE	system operation with full functionality
VYL	system operation without information transfer from track infrastructure
ZAV	rail vehicle as dead in pulling or pushing

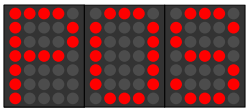
Staff carries out the operating mode selection on signal repeater at active driver´s cab (more detailed in Section 24). At operating mode change, the vehicle must have zero speed. Operating mode change is not possible and is immediately interrupted in case of train protection intervention and in case of detected system error.

When transferring control between DRV cabs, the set system operating mode is maintained. The operating mode setting expires only with switching-off the system-powering battery source.

Setting procedure of LS operating modes on signal repeater is as follows:

- 1x button +, display: **REZ**
- 1x button ↵, display: **initial operating mode** flashes
- setting of new operating mode − / +, display: **POS** ↔ **PRE** ↔ **VYL** ↔ **ZAV** flashes
- 1x button ↵, display: **new operating mode** permanently lit

11.1 POS – Shunting Operating Mode (LS)



Train protection runs in POS operating mode when manipulating with driving rail vehicle in stations, railway yards and during shunting with driving vehicle. The mode is aimed for DRV travel at low speeds, with frequent driver´s cab change.

Transfer of Railway signals

In the POS operating mode, the transfer of information from track infrastructure isn´t active, railway signals aren´t displayed on signal repeater and detection of code carrying frequency isn´t carried out.

Vigilance Supervision

In the POS operating mode, the train driver is obliged to demonstrate vigilance by operating the vigilance buttons once after vehicle´s setting into motion and cyclically starting form speed of 20 $km.h^{-1}$. At lower speeds, the train driver doesn´t need to demonstrate his vigilance. Should the train driver fail to confirm his vigilance after vigilance prompting, a system intervention (NZ1) takes place and emergency brake gets activated.

Maximum Speed Supervision

In the POS operating mode, the train protection supervises the DRV travel speed, with maximum speed indicated on NO11 signal repeater display. When violating maximum speed by more than 7 $km.h^{-1}$, a system intervention (NZ2) occurs and emergency brake gets activated.

Maximum speed in a given moment is determined as the lowest among following ones:

- maximum vehicle design speed
- maximum speed for operating mode
- maximum permitted speed

Maximum speed for POS operating mode has been set to 40 $km.h^{-1}$. The train driver hasn´t any possibility to alter this maximum speed. Maximum speed based on railway signal isn´t monitored and hasn´t any influence on system operation in the POS operating mode.

Supervision of Accord Between Actual and Selected Travel Direction

In the POS operating mode, the train protection supervises accord and discord of actual travel direction and the selected travel direction. Discord is evaluated for each movement of driving vehicle. Accord is required for movement with any speed exceeding 5 $km.h^{-1}$. At drive vehicle travel in a direction, which isn´t in accord with the selected travel direction, after 10 m a system intervention (NZ3) occurs and emergency brake gets activated. With cabin switch OFF at both rail vehicle driver´s cabs, any movement is evaluated as movement in contrary with the selected travel direction.

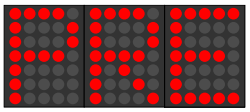
Remote Stop

The remote stop function is active, if permitted by system configuration, if allowed by organizational provisions of the operating company and the radio station features respective function. At activation a system intervention (NZ4) occurs and emergency brake gets activated.

Supervision of Safety against Spontaneous Movement

The MIREL VZ1 train protection checks safety of a rail vehicle at standstill against spontaneous movement. Should, within a predetermined time (25 s / 100 s) after brake release, the rail vehicle not start to move, a system intervention (NZ5) occurs and emergency brake gets activated.

11.2 PRE – Operating Mode Operation (LS)



In the PRE operating mode, all operating functionalities of MIREL VZ1 train protection are activated according to LS specification. The mode is used at standard DRV operation.

Transfer of Railway signals

In the PRE operating mode, when running on rail lines with transfer of information from rail line infrastructure, the system carries out transfer of railway signals to signal repeater. The signal sensed from track infrastructure id filtered and decoded. The resulting railway signal is displayed on signal repeater. The train protection system performs simultaneously an automatic detection of rail line infrastructure carrying frequency.

If the train protection system is operated in configuration without transfer of information from rail line infrastructure, the transfer of railway signals isn´t performed even in PRE mode.

Vigilance Supervision

In the PRE operating mode, the train driver is obliged to demonstrate vigilance by operating the vigilance buttons in situations as follows:

- one-time check after rail vehicle movement start
- cyclically, if there isn´t any transfer of railway signals
- increased cyclical supervision in the MANUAL mode
- increased cyclical supervision when transferring the stop indication after braking curve accomplishment
- increased cyclical supervision at transfer of warning signal after braking curve accomplishment, if vehicle speed is > 90 $km.h^{-1}$
- increased cyclical supervision at transfer of signal 40 and warning, if staff has increased the target speed to over 40 $km.h^{-1}$
- one-time vigilance supervision when modelling the braking curve

Meeting one of following conditions cancels the obligation to demonstrate vigilance:

- DRV at standstill
- travel speed is < 15 $km.h^{-1}$ with engaged direct-acting brake

Should the engine driver fail to confirm his vigilance after vigilance prompting by pushing the button or pedal, a system intervention (NZ1) occurs and emergency brake gets activated.

Maximum Speed Supervision

In the PRE operating mode, the train protection system compares the current DRV speed with the maximum speed as displayed on NO11 signal repeater display. At violating the maximum speed with a tolerance of 7 $km.h^{-1}$, a system intervention (NZ2) occurs and emergency brake gets activated. During braking curve modelling, the tolerance of maximum speed violation is temporarily suppressed and the system intervenes immediately after maximum speed violation. The engine driver has the option to switch the device to MAN mode during braking curve modelling.

In the MAN mode, at lower speed than 120 $km.h^{-1}$, the maximum speed is speed of 120 $km.h^{-1}$. When switching the device to MAN mode at a speed higher than 120 $km.h^{-1}$, the actual speed of rail vehicle travel becomes the maximum speed and the maximum speed can only decrease. This means, that the train driver can´t accelerate above the speed (with respective tolerance) to which the vehicle has already decelerated during the MAN mode. With speed dropping under 120 $km.h^{-1}$, this speed of 120 $km.h^{-1}$ becomes the maximum speed.

Maximum speed at a given moment is determined as the lowest among following ones:

- maximum vehicle design speed
- maximum speed for operating mode
- pre-set speed
- maximum speed according to railway signal
- maximum permitted speed

Maximum speed for PRE operating mode has been set to 160 km.h^{-1}. The train driver hasn´t any possibility to alter this maximum speed.

Supervision of Accord Between Actual and Selected Travel Direction

In the PRE operating mode, the train protection strictly supervises the accord of actual travel direction with the selected direction. Accord is required for any movement of driving vehicle. At drive vehicle movement in a direction, which isn´t in accord with the selected direction, after 10 m a system intervention (NZ3) occurs and emergency brake gets activated. With control switch OFF at both rail vehicle driver´s cabs, any movement is evaluated as movement in contrary to the selected travel direction.

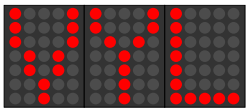
Remote Stop

The remote stop function is active, if permitted by system configuration, if allowed by organizational provisions of the operating company and the radio station features respective function. At activation, a system intervention (NZ4) occurs and emergency brake gets activated.

Supervision of Safety against Spontaneous Movement

The MIREL VZ1 train protection checks safety of a rail vehicle at standstill against spontaneous movement. Should, within a predetermined time (25 s / 100 s) after brake release, the rail vehicle not start to move, a system intervention (NZ5) occurs and emergency brake gets activated.

11.3 VYL – Lockout Operating Mode (LS)



In the VYL operating mode, the train protection operates identically like in the PRE operating mode, with exception of blocking the information transfer from rail line infrastructure. The system operation is the same like in the PRE mode on a uncoded rail line. The lockout mode is applied in cases, when the train driver gets a command regarding a lockout of rail line part of train protection and there is a risk, that the mobile part would transmit incorrect railway signals.

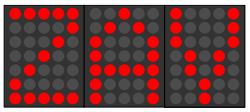
Maximum speed for VYL operating mode has been set to 120 $km.h^{-1}$. The engine driver hasn´t any possibility to alter this maximum speed.

In the VYL mode, the system doesn´t carry out within the scope of D2 diagnostic test any continuous check-up of transfer path signal sensing from rail line infrastructure. A one-time diagnostic check-up of transfer path for signal sensing from rail line infrastructure within the scope of D1 diagnostic test is carried out by the system in all operating modes.

Vigilance supervision, maximum speed supervision, supervision of accord between selected and actual travel direction, the possibility of remote stop and supervision of safety against spontaneous movement remain the same like in the PRE operating mode.

If the system is in configuration without transfer of information from rail line infrastructure, there isn´t any difference between operation in the VYL and PRE operating modes.

11.4 ZAV – Dead-in-Tow Operating Mode (LS)



Train protection works in ZAV operating mode during rail vehicle pushing or at train DRV when more DRV´s have been arranged at train head.

Signal Transfer

In the ZAV operating mode, the transfer of information from rail line infrastructure isn´t carried out, neither railway signals are displayed on signal repeater, nor the detection of carrying code frequency is carried out.

Maximum Speed Supervision

In the ZAV operating mode, the train protection compares the current DRV speed with the maximum speed as displayed on NO11 signal repeater display. At maximum speed violation by more than 7 $km.h^{-1}$, a system intervention (NZ2) occurs and emergency brake gets activated.

Maximum speed at a given moment is determined as the lower between following ones:

- maximum DRV design speed
- maximum speed for operating mode

Maximum speed for ZAV operating mode has been set to 160 $km.h^{-1}$. The engine driver hasn´t any possibility to alter this maximum speed.

Set target speed, maximum speed according to railway signal and highest permitted speed aren´t supervised and don´t have any effect on system operation in the ZAV operating mode.

Vigilance Supervision

Driver´s vigilance isn´t supervised in the ZAV operating mode.

Supervision of Accord Between Actual and Selected Travel Direction

In the ZAV operating mode, the train protection supervises the accord of actual travel direction with the selected direction. Discrepancy is evaluated for any movement of driving vehicle. Accord is required for travel with any speed higher than 5 $km.h^{-1}$. At drive vehicle´s movement in a direction, which isn´t in accord with the selected direction, after 10 m a system intervention (NZ3) occurs and emergency brake gets activated. With control switch OFF at both rail vehicle driver´s cabs, any movement is evaluated as movement in contrary to the selected travel direction.

Remote Stop

The remote stop function is active, if permitted by system configuration, if allowed by organizational provisions of the operating company and the radio station features respective function. At activation a system intervention (NZ4) occurs and emergency brake gets activated.

Supervision of Safety against Spontaneous Movement

The MIREL VZ1 train protection checks safety of a rail vehicle at standstill against spontaneous movement. Should, within a predetermined time (25 s / 100 s) after brake release, the rail vehicle not start to move, a system intervention (NZ5) occurs and emergency brake gets activated.

12 LS Operating Functionalities

Operating Mode	POS	PRE	VYL	ZAV
Information Transfer from Rail Line Infrastructure	–	✓	–	–
Automatic Detection of Infrastructure Carrying Frequency	–	✓	–	–
Maximum Speed Supervision	✓	✓	✓	✓
Maximum Design Speed Supervision	✓	✓	✓	✓
Operating Mode Maximum Speed Supervision [km.h^{-1}]	40	160	120	160
Pre-set Speed Supervision	✓	✓	✓	–
Supervision of Maximum Speed According Signal Aspects	–	✓	–	–
Setting of Target Speed for Signal „40 and Warning“	–	✓	–	–
Highest Permitted Speed Supervision	✓	✓	✓	–
Braking Curve Supervision	–	✓	–	–
MAN Mode	–	✓	–	–
Supervision of Passing Beyond the STOP-Signal	–	✓	–	–
Vigilance Supervision	✓	✓	✓	–
Cyclical Vigilance Supervision	✓	✓	✓	–
Increased Cyclical Vigilance Supervision	–	✓	–	–
One-time Vigilance Check-up based on Information from Infrastructure	–	✓	–	–
One-time Vigilance Check-up after DRV Start	✓	✓	✓	–
Inspection of Actual and Selected Travel Direction	✓	✓	✓	✓
Remote Train Stop	✓	✓	✓	✓
Supervision of Safety against Spontaneous Movement	✓	✓	✓	–
Notification about Enabling Signal	–	✓	–	–

12.1 Transfer of Information from Rail Line Infrastructure (LS)

In the PRE operating mode on lines equipped with LS rail line infrastructure, transfer of railway signals to signal repeaters takes place. The system reads signal from rail line infrastructure, filters and decodes it. The decoded signal is displayed on signal repeater.

The train protection performs carrier code frequency detection (50 Hz / 75 Hz). Dependent on the detected carrier frequency, it automatically sets parameters of signal transfer path from rail line infrastructure. The automatic carrier frequency detection is deactivated in case of electric driving rail vehicle operation on lines with 50 Hz traction feed. In such cases, transfer filters operate permanently at 75 Hz. The detected carrier frequency is indicated on the active signal repeater with **75** (NO7) or **50** (NO8).

Based on information transmitted from rail line infrastructure, the system decodes railway signal, which is displayed on signal repeater of active cab as follows:

Railway signal	Symbol	Indicator
Clear		NO3
Warning		NO1
40 and warning		NO4
Stop		NO2

Simultaneously with railway signal on indicators NO1 through NO4, the target speed or its alteration corresponding with indicated signal is displayed on NO11 signal repeater display.

In other operating modes based on LS specification (POS, VYL, ZAV), the transfer of information from rail line infrastructure and railway signal isn´t carried out.

In all operating modes, the system performs within the scope of one-time D1 diagnostic test a check-up of transfer path of information sensing from rail line infrastructure. In the PRE operating mode, within the scope of D2 continuous diagnostics, the system carries out a check-up of information transfer from rail line infrastructure permanently during the entire operation.

If the train protection system is operated in a configuration without transfer of signal aspects (it isn´t equipped with filters of signal aspect transfer and code sensors haven´t been connected), the transfer of information from rail line infrastructure and diagnostics of transfer path aren´t carried out.

12.2 Maximum Speed Supervision (LS)

The maximum speed at a given moment is determined as the lowest one from speeds provided in Table below. Which of the speeds are included into maximum speed evaluation, is dependent on system operation mode.

	POS	PRE	VYL	ZAV
Maximum DRV design speed (12.3)	✓	✓	✓	✓
Maximum speed acc.to operating mode (12.4)	✓	✓	✓	✓
Pre-set speed (12.5)	✓	✓	✓	–
Maximum speed acc.to railway signal (12.6)	–	✓	–	–
Highest permitted speed (12.10)	✓	✓	✓	–

Maximum speed displayed on signal repeater isn´t the permitted speed. The permitted speed can be, dependent on rail line- and operating conditions lower than the displayed maximum speed, which is supervised by train protection system.

The train protection compares maximum speed as displayed on signal repeater, with the current travel speed. When violating the maximum speed by more than 3 $km.h^{-1}$, the system activates visual indication. The figure on signal repeater display at active driver´s cab starts to flash with a frequency of 2,5 Hz. When violating the maximum speed by more than 5 $km.h^{-1}$, the engine driver is, along with visual indication, alerted by ZS2 audible signal. When violating the maximum speed by more than 7 $km.h^{-1}$, a NZ2 system intervention and emergency brake activation occurs.

During braking curve modelling (described in Section 0) all tolerances of maximum speed supervision are temporarily set to zero. In such case the system intervenes after each maximum speed violation. The standard tolerance level (+3, +5, +7 $km.h^{-1}$) is restored, when the maximum speed in the modelled braking curve reaches the target speed value + 7 $km.h^{-1}$.

At system operation in MAN mode, the maximum speed according to railway signal is determined in dependence on rail vehicle speed. At DRV speed above 120 $km.h^{-1}$, in the moment of MAN operating mode, the current travel speed of rail vehicle becomes the maximum speed according to railway signal. In course of further operation in MAN mode, the maximum speed according to railway signal can only decrease, in accordance with decreasing rail vehicle speed. At DRV speed of up to 120 $km.h^{-1}$, including, the maximum speed in MAN mode according to railway signal is constantly 120 $km.h^{-1}$.

The system evaluates alteration of measured travel speed at DRV´s axle. If the speed increase or decrease is disproportionately high, the system detects adhesion loss at measured axle. After adhesion loss detection, the maximum speed supervision is limited. System performs visual and audible signalling of maximum speed violation in comparison with actually measured travel speed. Within a 10 s time period from adhesion loss detection, the system doesn´t perform any train control intervention check-up at maximum speed violation. After expiration of the 10 s-period from adhesion loss detection, the maximum speed supervision is restored in full extent.

12.3 Maximum Design Speed Supervision (LS)

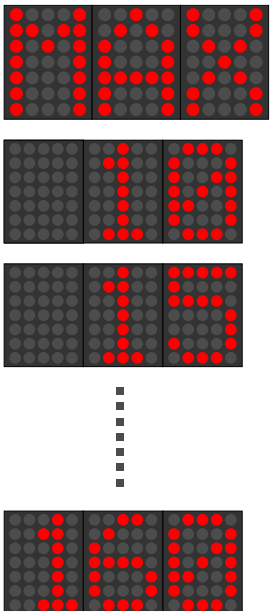
In each operating mode according to LS-specification, the system supervises maximum design speed of rail vehicle. The maximum design speed is determined by the train protection configuration and train staff hasn´t any option to alter this speed. If the maximum rail vehicle design speed is higher than 160 $km.h^{-1}$, the maximum design speed in the system configuration is, compliant with MIREL VZ1 train protection operating range, set to 160 $km.h^{-1}$.

12.4 Supervision of Maximum Speed for Operating Mode (LS)

All operating modes according to LS-specification feature a defined maximum speed for operating mode. The operating mode maximum speed is fixed and neither train staff, nor service personnel have any option to alter this speed. Maximum speed values for the operating mode are provided in Table below.

	POS	PRE	VYL	ZAV
Maximum Speed for Operating Mode	40 $km.h^{-1}$	160 $km.h^{-1}$	120 $km.h^{-1}$	160 $km.h^{-1}$

12.5 Set Speed Supervision (LS)



At operation in POS, PRE and VYL operating modes, the train protection supervises the set speed.

Set speed is an operating parameter, which is set by DRV´s staff. Speed is set for a specific train based on train schedule booklet. The driver can alter set speed in any mode, but for the ZAV operating mode, the setting of speed hasn´t any effect.

Setting of set speed is enabled only at rail vehicle at standstill.

After the train protection is switched on, the set speed is determined in accordance with system configuration (in general from 60 to 70 % from maximum design speed).

Staff can alter the set speed in the range from 10 km.h^{-1} up to maximum rail vehicle design speed in steps of 5 km.h^{-1}. It is not possible to set higher speed than the maximum rail vehicle design speed. At entering of set speed, staff follows procedure outlined in Section 24.

Setting-up procedure of set speed at signal repeater is as follows:

- 2x button , display: **MAX**
- 1x button , display: **initially set speed** flashes
- Setting-up of set speed / , display: **10** ↔ **15** ↔ **20** ↔ ... ↔ **155** ↔ **160** flashes
- 1x button display: **newly set speed** permanently lit

When transferring control between rail vehicle cabs, the set speed remains preserved. The setting of set speed perishes only after system feed switch-off. After next system start, the set speed is initialized to implicit value.

12.6 Maximum Speed Supervision Based on Railway signals (LS)

If the train protection is in the PRE operating mode, maximum speed supervision is influenced by speed resulting from transmitted railway signals.

Railway signals have assigned maximum speeds as follows:

Railway signal	Colour	Maximum speed
Clear		160 km.h^{-1} (with stable transfer) 120 km.h^{-1} (with unstable transfer)
Warning		120 km.h^{-1}
40 and warning		40 km.h^{-1} (alt. 60, 80, 100, 120 km.h^{-1})
Stop		40 km.h^{-1}
No transfer	–	120 km.h^{-1}

For the Clear railway signal, a continuous signal transfer lasting at least 5 s is regarded as stable transfer. Should the Clear signal transfer not last continuously 5 s, the transfer is considered to be unstable.

In case, that a new railway signal is transmitted to signal repeater within 5 s from transfer termination of previous signal and its maximum speed is lower than so far applicable maximum speed according to railway signals, the system doesn´t perform a one-time maximum speed alteration according to railway signals, but models a braking curve. Braking curve modelling is described in Section 12.7.

Should the transfer time period of the new signal, with maximum speed lower than the so far applicable maximum speed, last longer than 5 s, system automatically switches to MAN mode. System operation in the MAN mode is outlined in Section 12.8.

If a railway signal is transferred to signal repeater, which features a higher maximum speed than so far applicable maximum speed according to signals, the maximum speed according to railway signals is altered immediately.

At loss of signal 40 and warning transfer, if the maximum speed according to railway signals is lower than 120 km.h^{-1}, then the validity of last maximum speed according to railway signals is prolonged for the period of following 23 seconds. Should the loss of transfer last longer than 23 s, the maximum speed according to railway signals changes like on un-coded tracks.

With Stop signal transfer loss, the system activates supervision functionality of passing beyond STOP signal. Supervision of passing beyond the STOP-signal is outlined in Section 12.11.

12.7 Braking Curve Modelling (LS)

When the information transmitted from rail line infrastructure alters, the train protection models a braking curve from initial maximum speed to target speed in accordance with new railway signal. Braking curve modelling is carried out in case, that the train protection transmits a more stringent signal than the one transmitted before, or in case, that code transfer loss occurs at maximum speed higher than 120 km.h^{-1}.

During the braking curve modelling, the driver is alerted about the duty to decrease the speed by slowly flashing indicator (NO10). The device starts to calculate the braking curve with a braking distance of 1000 m. In the moment, when DRV reaches in the braking section the calculated braking curve start position, the current maximum speed on NO11 display starts to decrease. The driver has the duty to carry out such braking actions, that the current DRV speed is lower than the gradually decreasing maximum speed. Braking curve modelling terminates at end of braking distance.

Dependent on operating situation character, the train protection can deliver to the driver during braking curve modelling a one-time vigilance prompting, which differs in its sound from standard vigilance prompting (ZS1B audible signal). The one-time vigilance prompting notifies the driver about brake curve modelling and the necessity to operative decrease of current DRV speed. System provides a one-time vigilance prompting 10 s or 15 s before the anticipated braking curve violation. The 10 s time interval is used for cars with set speed above 100 km.h^{-1}. The 15 s time interval for cars with set speed 100 km.h^{-1} and less.

After output of one-time vigilance prompting, the indicator (NO10) flashes rapidly until termination of braking curve. If the one-time vigilance prompting is planned for 10 s and more from the start of brake curve modelling, system provides at start of braking curve modelling a repeated vigilance prompting (audible ZS1 signal). Both vigilance promptings must be acknowledged by driver in the common way.

Braking curves are modelled with parameters as follows:

Braking distance:

- 1000 m

Safety factor:

- 10 %

Feedback times:

- 3 s train protection feedback time,
- 2 s staff feedback time,
- 3,5 / 2,5 / 1,5 s brake feedback time, dependent on set speed.

Deceleration:

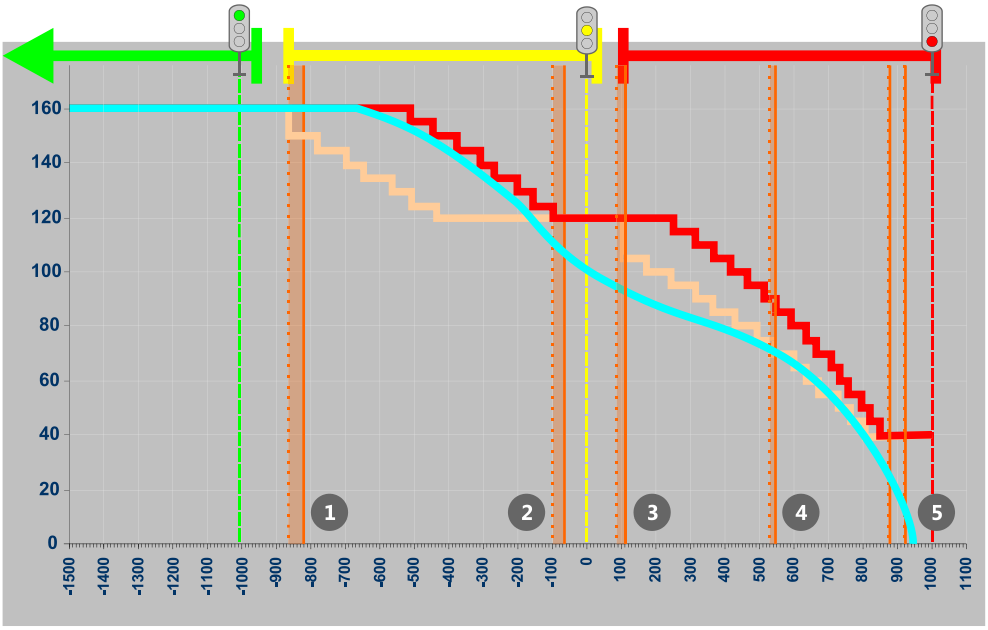
- 0,40 m.s-2 for set train speeds of up to 80 km.h^{-1} (including),
- 0,60 m.s-2 for set train speeds of up to 100 km.h^{-1} (including),
- 0,82 m.s-2 for set train speeds of up to 140 km.h^{-1} (including),
- 0,94 m.s-2 option 1 for set train speeds above 140 km.h^{-1},
- 1,50 m.s-2 option 2 for set train speeds above 140 km.h^{-1}.

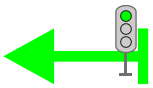
During braking curve modelling, the tolerance of visual and audible signalling of maximum speed violation and of train protection intervention at maximum speed violation are temporarily disabled. System intervenes immediately after braking curve violation.

During braking curve modelling, the driver can switch the train protection to MAN mode.

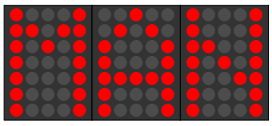
In case, that the 5-second limit for transfer of new railway signal after termination of previous signal transfer is surpassed and the new signal is more stringent than the old one, system automatically switches to MAN mode and abstains from braking curve modelling. System switches automatically to MAN mode also in the case, if during braking curve modelling a skid or slide is detected.

The picture below shows an example of braking curve modelling for rail vehicle braking from a speed of 160 km.h^{-1} until stopping. Braking is carried out over 2 rail line sections.



axis X	travelled distance [m]
axis Y	speed [km.h^{-1}]
	rail line section with Clear railway signal transfer
	rail line section with Warning railway signal transfer
	rail line section with Stop railway signal transfer
	intervention braking curve, its violation leads to system intervention
	information braking curve, its violation leads to output of one-time vigilance challenge
	actual DRV speed
1	one-time vigilance prompting for braking curve 160 → 120 km.h^{-1}
2	increased cyclical vigilance supervision at travel in front of Warning signal
3	repeated one-time vigilance prompting for braking curve 120 → 0 km.h^{-1}
4	one-time vigilance prompting for braking curve 120 → 0 km.h^{-1}
5	increased cyclical vigilance supervision at travel in front of Stop signal

12.8 MAN Mode (LS)



During braking curve modelling, the driver can take over maximum speed supervision by means of switching the system to MAN mode. In below stated defined cases system activates the MAN mode automatically without driver´s command. Mode termination occurs automatically.

Typical reasons for MAN mode activation by the driver are following ones:

- significantly longer track section than projected braking curve length,
- short-term code transfer errors,
- considerably different travel dynamic, than assumed projected braking curve.

Driver performs the MAN mode activation by pushing the button (NO14) on signal repeater. Activation can be carried out only when system is modelling the braking curve, indicator (NO10) flashes.

MAN output is displayed on signal repeater display (NO11) and indicator **M** (NO9) switches on. After 5 seconds, the output **MAN** on display is substituted by target speed resulting from transmitted railway signal. Target speed indication flashes (2,5 Hz).

If the transfer of new stable railway signal after transfer termination of old signal lasted longer than 5 s and the new railway signal is more stringent than the old one, system automatically switches to MAN mode.

System switches automatically to MAN mode also in the case, that an adhesion loss occurs during braking curve modelling.

When system has been switched to MAN mode, the driver must watch the operating situation of the rail vehicle, taking into account reasons leading the train protection to decrease the maximum speed to target speed. By switching the system to MAN mode, the driver takes over the responsibility for maximum speed supervision.

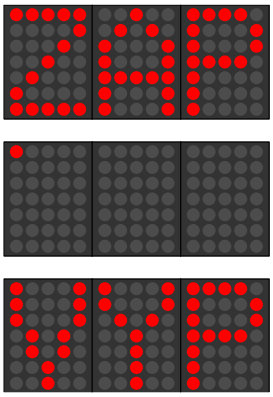
In the MAN mode at travel speed of up to 120 $km.h^{-1}$, the maximum speed according to railway signal is 120 $km.h^{-1}$. In case when switching the system to MAN mode at a speed higher than 120 $km.h^{-1}$, the actual rail vehicle travel speed becomes the maximum speed according to railway signal. During MAN mode, this maximum speed can only decrease in accordance with decreasing rail vehicle speed. This means, that the driver can´t accelerate above the speed level (with corresponding tolerance) to which the vehicle has already decelerated during MAN mode. When travel speed drops under 120 $km.h^{-1}$, then 120 $km.h^{-1}$ becomes the maximum speed according to railway signal and remains without change until termination of MAN mode.

Termination of MAN mode occurs automatically after braking to target speed, or upon receipt of a different railway signal, having a higher speed then the actual speed of DRV. After termination of MAN mode, the **M** indicator (NO9) goes out and the train protection takes over maximum speed supervision in extent as specified in Section 12.2.

12.9 Target Speed Increasing for Signal 40 and Warning (LS)

The basic maximum speed for the signal 40 and warning is 40 km.h^{-1}. When such railway signal is being transmitted, the staff has the option to increase the target speed to values of 60, 80, 100 or 120 km.h^{-1} by means of a single-touch action. Decrease of this speed is not allowed. Increase is carried out by pushing the button  (NO13) on signal repeater. Each operating of PLUS-button increases speed by 20 km.h^{-1}. Such increased target speed applies until transfer of a different signal or until a moment, when the train protection starts to operate like at an un-coded rail line.

12.10 Highest Permitted Speed Supervision (LS)



Highest permitted speed can be set by driver on a DRV in motion from 10 km.h^{-1} up to maximum design speed. The highest permitted speed is set according to current travel speed of the rail vehicle, rounded off to whole 5 km.h^{-1}. The current travel speed of rail vehicle is rounded off to -1, +3 km.h^{-1}.

Driver has the option to switch-on and -off the supervision of highest permitted speed by means of a single-touch selection on signal repeater, by operating the button (NO12). Switching on the control is enabled only with rail vehicle in motion. Switching off the highest permitted speed is allowed also with a motionless vehicle. The set highest permitted speed when switching-on applies until switching-off the supervision of highest possible speed. The highest permitted speed can´t be set higher than the actual rail vehicle maximum speed.

After switching on the supervision of highest permitted speed, output **ZAP** (i.e. ON) emerges on display NO11 for 5 seconds. Activated highest permitted speed supervision is indicated on signal repeater by permanently lit red dot in the left upper corner of NO11 display. After switching off, the output **VYP** (i.e. OFF) emerges on display NO11 for 5 seconds.

Supervision of highest permitted speed can´t be switched –on or –off during braking curve modelling.

12.11 Supervision of Passing Beyond STOP Signal (LS)

When the rail vehicle passes by a signal head in STOP position, the transfer of red railway signal, which has been transmitted to signal repeater ahead of signal head, is terminated. The rail vehicle enters an occupied line section, in which there isn´t any information transfer from line section. Train protection detects such situation and automatically activates the function of supervising any passing beyond the STOP signal.

If a permanent transfer loss occurs after a stable STOP signal transfer, system continues to supervise the maximum speed for Stop railway signal. For switching the system to mode like on un-coded tracks, the prerequisite of travelling a distance of 1000 m after Stop signal transfer loss is supervised apart from the 23-second prerequisite (in compliance with Section 12.6). Only after meeting both prerequisites, the system evaluates the existing situation as operation on an un-coded track and alters maximum speed for railway signals.

Prerequisite of travelled distance of 1000 m isn´t activated at transfer loss of other railway signal than the red signal aspect.

12.12 Vigilance Supervision (LS)

The train protection performs the driver´s vigilance supervision by means of providing audible vigilance promptings, which have to be confirmed by driver by means of vigilance pushbuttons, pedals or controllers.

Two vigilance pushbuttons are generally located at each rail vehicle cab. A cab can be equipped also with vigilance pedals. Vigilance can be confirmed by means of pushbutton or pedal only if the cabin switch has been engaged at the respective cab. Use of vigilance pedals can be disabled by system configuration.

Vigilance pushbutton or pedal must be operated at least for 50 ms. Permanent pushing down of a button or pedal doesn´t result in repeated vigilance confirmation.

Some steering controllers at rail vehicle cab can be connected to vigilance confirmation circuits as well. Usually this applies for steering controller and braking device. By means of steering controllers vigilance can be confirmed only at active driver´s cab. Specific connection of individual steering controllers at driver´s cab to train protection circuits depends on rail vehicle type.

When confirming vigilance by manipulating with steering controllers, the minimum time period of 50 ms must be adhered to when passing through positions of such controllers, which are not arrested.

In case of emerged duty to confirm vigilance on signal repeater, latest in 2 seconds the indicator (NO5) goes out and first audible vigilance prompting is provided. With rail vehicle speed of more than 40 $km.h^{-1}$, the first vigilance confirmation after duty to confirm the vigilance can be carried out only by means of vigilance buttons or vigilance pedals. With rail vehicle speed of up to 40 $km.h^{-1}$, also the first vigilance confirmation can be carried out with steering controllers. A repeated vigilance confirmation can be carried out independently from rail vehicle speed by means of vigilance buttons, pedals or by manipulation of steering controllers.

If the driver hasn´t duty to confirm his/her vigilance, the indicator (NO5) is lit on signal repeater. If indicator isn´t lit, the driver can confirm vigilance independently from the fact, whether the sound vigilance prompting has been provided or not. In case, when driver presses the vigilance button or pedal with a lit indicator , system alerts the driver in some situations to unprompted vigilance confirmation by activating audible ZS8 signal.

3,5 s before the end of vigilance interval, the system provides driver at active cab with audible vigilance prompting (signal ZS1 or ZS1B), which must be confirmed by driver in the above-mentioned way. If this doesn´t happen until the end of vigilance interval, system intervenes (NZ1) and activates emergency brake. Each vigilance prompting must be confirmed. Depending on the configuration, the system can also provide a visual alertness on the external indicator in advance.

Vigilance supervision can be cyclical or one-time and is carried out dependent on active system operating mode.

	POS	PRE	VYL	ZAV
cyclical vigilance supervision (12.13)	✓	✓	✓	–
increased cyclical vigilance supervision (12.14)	–	✓	–	–
one-time vigilance supervision based in information from infrastructure (12.15)	–	✓	–	–
one-time vigilance supervision after setting of DRV into motion (12.16)	✓	✓	✓	–

12.13 Cyclical Vigilance Supervision (LS)

Cyclical vigilance supervision is a standard way of driver´s vigilance supervising, which is carried out at system operation without transfer of information from rail line infrastructure. Vigilance cycle length is based on time interval. In order to protect against stereotype, the vigilance cycle length is variable and depends on actual DRV speed. Cyclical vigilance supervision is performed in following cases:

- In POS operating mode at DRV speeds higher than 20 km.h^{-1}.
- In PRE operating mode at non-zero speed of DRV, if the direct-acting brake hasn´t been engaged and there isn´t any railway signal transfer. Stopping of DRV terminates the duty to confirm vigilance. Standard vigilance supervision isn´t required during transfer of signal aspects. In some operating situations an increased vigilance supervision is required (Section 0). Action of direct-acting brake at a speed lower than 15 km^{-1} terminates the duty to confirm vigilance. Braking of direct-acting brake at a speed higher than 15 km^{-1} has no effect on the duty to confirm vigilance.
- In the VYL operating mode identically like in the PRE operating mode.
- In the ZAV operating mode, the cyclical vigilance supervision isn´t being performed.

At a DRV travel speed below 30 km.h^{-1}, the vigilance interval is 24 s. Within this interval, first 6 s the indicator (NO5) is lit and vigilance can´t be confirmed. For the last 3,5 s of the interval, system provides audible ZS1 vigilance prompting.

With DRV movement at higher speeds, the interval gets shorter. At DRV speed above 110 km.h^{-1} the interval of vigilance confirmation is 16 s. Within this interval, first 4 s the indicator is lit and vigilance can´t be confirmed. The length of audible ZS1 vigilance prompting is constantly 3,5 s and is not dependent on DRV speed.

An eventual audible prompting is terminated with vigilance confirmation and indicator is lit. With vigilance confirmation, the interval starts to run from the beginning. Should vigilance not be confirmed until the interval end, system intervenes NZ1 and activates the emergency brake.

12.14 Increased Cyclical Vigilance Supervision (LS)

Increased cyclical vigilance supervision is a way of driver vigilance check in operating situations requiring increased attention. Activation of increased cyclical vigilance supervision is carried out based on information transferred from rail line infrastructure. The vigilance cycle length is based on a time interval and is fixed. Cyclical vigilance supervision is performed in following cases.

- In the PRE operating mode with activated MAN mode
- In the PRE operating mode with Stop signal transfer after termination of eventual braking curve modelling. Stopping of DRV terminates the increased cyclical vigilance supervision. Action of direct-acting brake at a speed lower than 15 km^{-1} terminates the increased cyclical vigilance supervision. Braking of direct-acting brake at a speed higher than 15 km^{-1} has no effect on increased cyclical vigilance supervision.
- In the PRE operating mode with transfer of signal 40 and warning and increasing of target speed for this signal to 60 $km.h^{-1}$ and more. Stopping of DRV terminates the increased cyclical vigilance supervision. Action of direct-acting brake at a speed lower than 15 km^{-1} terminates the increased cyclical vigilance supervision. Braking of direct-acting brake at a speed higher than 15 km^{-1} has no effect on increased cyclical vigilance supervision.
- In the PRE operating mode with transfer of Warning signal after termination of eventual braking curve modelling, if actual DRV speed is higher than 90 $km.h^{-1}$.

Independently from DRV speed, the interval of increased vigilance supervision is 12 s. Within this interval, the first 8,5 s indicator (NO5) is lit and vigilance can´t be confirmed. Final 3,5 s from interval, the system delivers audible ZS1 vigilance prompting and vigilance can be confirmed. Without the delivery of vigilance prompting, the vigilance can´t be confirmed with increased vigilance control.

An eventual audible prompting is terminated by vigilance confirmation and indicator gets permanently lit. After vigilance confirmation interval starts to be calculated again from beginning. Should vigilance not be confirmed until interval expiry, system intervenes NZ1 and activates emergency brake.

12.15 One-time Vigilance Supervision According Information from Infrastructure (LS)

A one-time vigilance supervision based on information from infrastructure notifies driver about braking curve modelling and about the necessity of operating reduction of actual DRV speed. Immediately after (NO5) goes out, system delivers to driver a one-time vigilance prompting ZS1B, which is audibly different from other ZS1 vigilance promptings. Length of vigilance prompting is 3,5 s. Driver confirms his/her vigilance in a standard way. After vigilance confirmation, the audible prompting is terminated and indicator starts lighting. Should vigilance not be confirmed until interval expiry, system intervenes NZ1 and activates emergency brake.

A one-time vigilance control based on information from infrastructure is activated during braking curve modelling. In a situation, when train protection calculates that with continuation of DRV travel at constant speed, the intervention braking curve gets violated in time t_R, system delivers to driver a one-time vigilance prompting. For pre-set speeds of 100 $km.h^{-1}$ and less, the time t_R is set to 15 s. For pre-set speeds of over 100 $km.h^{-1}$ the time t_R is set to 10 s. A one-time vigilance prompting is delivered only once during braking curve modelling.

If a one-time vigilance prompting based on information from infrastructure has been designed as 10 s and more from the start of braking curve modelling, then the system switches off the indicator at beginning of braking curve and delivers a repeated vigilance prompting to driver. Repeated vigilance prompting isn´t audibly different from standard ZS1 vigilance prompting. Length of vigilance prompting is 3,5 s. Driver confirms his/her vigilance in a standard way. After vigilance confirmation, the audible prompting is terminated and indicator gets permanently lit. Should vigilance not be confirmed until interval expiry, system intervenes NZ1 and activates emergency brake.

12.16 One-time Vigilance Supervision after Setting DRV into Motion (LS)

If, after setting DRV into motion, the cyclical vigilance supervision isn´t active, the indicator (NO5) goes out and system delivers to driver exactly one standard ZS1 vigilance prompting. Length of vigilance prompting is 3,5 s. Driver confirms his/her vigilance in a standard way. After vigilance confirmation, the audible prompting is terminated and indicator gets permanently lit. Should vigilance not be confirmed until interval expiry, system intervenes NZ1 and activates emergency brake.

One-time vigilance supervision after putting DRV into motion is active in operating modes POS, PRE and VYL.

12.17 Supervision of Accord Between Actual and Selected Travel Direction (LS)

The train protection evaluates rail vehicle travel direction from signals of axle speed sensor. Such evaluated travel direction is compared with the preselected direction on direction selector at active cab. Their accord or discord is checked. Following 5 cases can occur during rail vehicle operation.

1. If the rail vehicle follows after setting into motion the direction, which corresponds with the one preselected by driver at active cab, then such travel direction is classified as permitted one. The permission for travel direction is valid until next stopping of rail vehicle, independent on eventual additional manoeuvres, which driver carries out with direction selector.
2. If the travel direction following setting of rail vehicle into motion hasn´t been classified as permitted and inverse direction to the actual one has been selected at active cab, after travelling a distance of 3 m the system activates ZS3 audible signal and after travelling a distance of 10 m system intervention NZ3 and emergency brake activation take place.
3. If the travel direction following setting of rail vehicle into motion hasn´t been classified as permitted and no direction has been selected at active cab, then:
    a) in PRE and VYL operating modes the system behaves identically like an inverse direction would have been selected according to clause 2,
    b) in POS and ZAV operating modes, the system reaction is analogous, with the one difference, that the rail vehicle travel distance in discord according to clause 2 starts to be counted only at a vehicle speed higher than 5 $km.h^{-1}$. Vehicle movement without engaged direction at a speed of up to 5 $km.h^{-1}$ is permitted in both directions.
4. If the D1 diagnostic test hasn´t been yet accomplished and pressure in the main brake line is lower than 3,5 bar, then all vehicle travel directions are permitted.
5. With steering switch in OFF position an both cabs, save operating situation stated in clause 4 , any rail vehicle movement is evaluated like travel in prohibited direction and system feedback is according to clause 2.

12.18 Remote Train Stop (LS)

The system functionality allows, in cooperation with DRV radio station, implementation of remote train stop command based on radio command. Decoding of train stop radio signal is carried out by DRV radio station. The remote train stop option is conditioned by train protection configuration, organizational provision of this function on infrastructural side as well as by DRV radio station equipment.

After receiving the remote stop command, the train protection activates audible ZS4 signal, intervenes NZ4 and activates emergency brake. Termination of NZ4 intervention is conditioned by termination of command from radio station and by DRV zero speed.

12.19 Supervision of Safety Against Spontaneous Movement (LS)

The MIREL VZ1 train protection checks the rail vehicle safety against spontaneous movement. Supervision takes place only on stopped HDV. Train protection supervises:

1. engagement of direct-acting (supplemental, locking) brake (pressure switch),
2. action of automatic brake with pressure in main braking line lower than 4,5 bar (pressure sensor).

After meeting of at least one from mentioned prerequisites, the system considers DRV safety against spontaneous movement to be sufficient. If neither the direct-acting, nor automatic brake is engaged, setting of vehicles into movement is assumed.

Time required for vehicle start is pre-set by system configuration in length of 25 s for DRV in passenger transport and 100 s for DRV in cargo transport. Should the DRV be at standstill 10 s from expiry of stated time, train protection notifies driver about this condition by means of audible ZS3 signal. If the entire pre-set time expires since brake release and DRV start or repeated braking doesn´t materialize, train protection intervenes (NZ5) and activates emergency brake.

Control of safety against spontaneous movement is performed in POS, PRE and VYL operating modes. Control isn´t carried out in the ZAV operating mode.

12.20 Notification of Enabling Signal (LS)

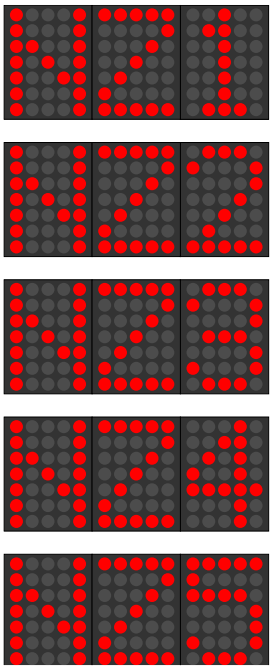
Train protection notifies driver of DRV at standstill or at low-speed travel about change of information transmitted from rail line infrastructure to information permitting further travel.

If at transfer of Stop railway signal, or in condition without information transfer from rail line infrastructure transfer changes to railway signal permitting travel continuation, train protection responds with audible ZS7 signal. Table below shows possible situations:

Old Railway signal	New Railway signal
Stop	Clear
without transmission	Clear
Stop	Warning
without transmission	Warning
Stop	40 and warning
without transmission	40 and warning

Function is active only in PRE operating mode, at DRV speed lower than 5 $km.h^{-1}$.

13 LS System Intervention



Reason for train protection intervention in LS national mode is the emerging of any of following situations:

Indication	Reason
NZ1	failing to confirm vigilance required by provided vigilance prompting (12.12)
NZ2	maximum speed violation (12.2)
NZ3	discrepancy between actual DRV travel direction and pre-set direction (12.17)
NZ4	remote train stop (12.18)
NZ5	failing to secure DRV against spontaneous movement 12.19)

Train protection intervention results in emergency brake activation. Train protection EPV opens after system intervention. Train protection intervention is signalled on flashing NO11 display on signal repeater of active cab by means of letters **NZ** and index of reason leading to emergency stop.

If reasons leading to intervention persist also after system intervention, intervention can´t be terminated. Driver is notified about this fact by audible train protection indication in accordance with the reason leading to intervention. Intervention can be terminated only when reasons leading to intervention cease to exist and/or DRV has achieved zero speed.

Reasons of NZ1 intervention are eliminated by vigilance confirmation by means of pressing the vigilance pushbutton or vigilance pedal at active cab, or by achieving zero speed of DRV. Audible ZS1 indication is terminated.

Reasons of NZ2 intervention are eliminated by DRV speed dropping under the value of current maximum speed, with zero tolerance. Audible ZS2 indication is terminated. At NZ2 intervention during braking curve modelling, DRV speed decrease under target speed resulting from transmitted railway signal is required.

Reasons of NZ3 intervention are eliminated by switching the direction selector into agreement with actual DRV travel direction or by DRV achieving zero speed. Audible ZS3 indication is terminated.

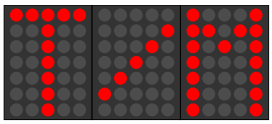
Reasons of NZ4 intervention are eliminated by DRV remote stop command termination and by DRV achieving zero speed. Audible ZS4 indication is terminated.

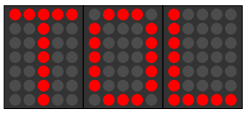
Reasons of NZ5 intervention are eliminated by securing of stopped DRV against spontaneous movement by means of engaging brake and stopping. Audible ZS3 indication is terminated.

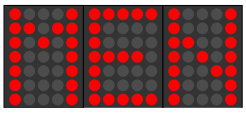
After elimination of reasons for train protection intervention, train staff can terminate emergency braking mode by pressing the pushbutton (NO14) on signal repeater of active cab. After cancelling the emergency stop mode, maximum speed appears on NO11 display and its flashing stops. Emergency brake EPV closes and rail vehicle is capable of further operation.

Each train protection intervention is registered.

14 EVM Operating Modes







The MIREL VZ1 train protection operates in EVM national mode in operating modes as follows:

Operating mode	Description
TOL	DRV shunting
MEN	system operation with full functionality

Staff carries out the operating mode selection on signal repeater at active driver´s cab (mode detailed in Section 24). At operating mode change, the rail vehicle mustn´t have speed higher than 40 km.h^{-1} and no maximum speed violation is permitted. Otherwise the change isn´t allowed to driver. Change of operating mode isn´t possible and is immediately interrupted in case of train protection intervention and in case of detected system error.

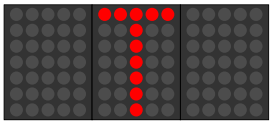
System activity in any of operating modes according to EVM specification is indicated on signal repeater by permanently lit **M** indicator (NO).

When transferring control between DRV cabs, the set system operating mode is preserved. The operating mode setting vanishes only with switching-off the system-powering battery source.

Setting procedure of LS operating modes on signal repeater is as follows:

- 1x button +, display: **T/M**
- 1x button ↵, display: **initial operating mode** flashes
- setting of new operating mode − / +, display: **TOL** ↔ **MEN** flashes
- 1x button ↵, display: **new operating mode** lights up

14.1 TOL – Shunting Operating Mode (EVM)



Train protection operates in TOL operating mode according to EVM specification when manipulating with driving rail vehicle in stations, yards and during shunting with driving vehicle. The operating mode is aimed for DRV movement at low speeds of up to 40 km.h^{-1}, with frequent driver´s cab change.

Transfer of Speed Indications

In the TOL operating mode, the system doesn´t perform transfer of information from rail line infrastructure and speed commands aren´t displayed on signal repeater. T-sign is permanently displayed on NO11 signal repeater display.

Vigilance Supervision

In the TOL operating mode, if DRV speed is higher than 15 km.h^{-1}, the driver is obliged to demonstrate his/her vigilance by confirming vigilance promptings. Train protection delivers vigilance promptings after travelling a distance of 1550 m. Distance measurement starts always from the moment of pressing the vigilance pedal or button. Distance of 150 meters is available for driver to confirm vigilance prompting. Should confirmation fail, train protection intervenes and activates emergency braking.

Maximum Speed Supervision

In the TOL operating mode, the train protection supervises the maximum speed for operating mode, which has been set to 40 km.h^{-1} with zero tolerance. At maximum speed violation, EPV is opened and emergency brake activated without any previous alert. EPV closing is carried out based on vigilance prompting confirmation. EPV closing is enabled only after the actual DRV speed has dropped below 15 km.h^{-1}.

Maximum speed in a given moment is determined as the lowest from following ones:

- maximum design speed
- maximum speed for operating mode

14.2 MEN – Operating Mode Operation (EVM)

In the MEN operating mode, all operating functions of MIREL VZ1 train protection according to EVM specification are activated. The operating mode is used at standard DRV operation.

Transfer of Speed Commands

In the MEN operating mode, transfer of information from rail line infrastructure is carried out in full extent. Received telegrams are decoded to speed commands which are displayed on signal repeater. In the basic condition, the valid speed command is displayed on NO11 signal repeater display, if available in the rail line section. The presence of 75 Hz carrying frequency in line circuits is indicated on signal repeater by means of indication light **75** NO7.

Another operating mode performed by train protection in the MEN operating mode is control of passing beyond of STOP signal. System evaluates this operating situation and if it materializes, speed command 0 is generated.

Vigilance Supervision

In the MEN operating mode, if DRV speed is higher than 15 $km.h^{-1}$, the driver is obliged to demonstrate his/her vigilance by confirming vigilance promptings. Train protection delivers vigilance promptings after travelling a distance of 1550 m. Distance measurement starts always from the moment of pressing the vigilance pedal or button. Distance of 150 metres is available for driver to confirm vigilance prompting. Should confirmation fail, train protection intervenes and activates emergency braking.

Maximum Speed Supervision

In the MEN operating mode, the train protection supervises maximum speed according to transmitted speed commands. Upon violation of maximum speed by more than 2 $km.h^{-1}$ (due to DRV speed change or due to transfer of a new speed command) train protection starts to generate frequent vigilance promptings, which are repeated each 200 m. If confirmation of promptings doesn´t occur, system opens EPV and activates emergency brake. Closing of EPV is enabled only after elimination of maximum speed violation. System accepts the confirmation of third and subsequent vigilance promptings only in case of pressure drop in main braking line (save speed command 1). System terminates delivery of frequent vigilance promptings in the moment when maximum speed violation is eliminated. In the increased speed mode, the interval of frequent vigilance promptings is reduced to 180 m and without pressure drop only the first vigilance prompting is enabled.

Maximum speed in a given moment is determined as the lowest among following ones:

- maximum design speed
- maximum speed for operating mode
- maximum speed according speed command

15 EVM Operating Functionalities

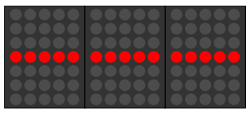
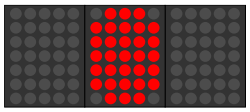
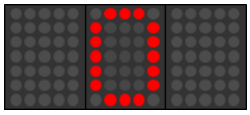
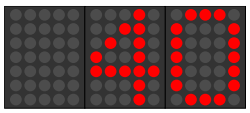
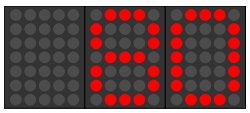
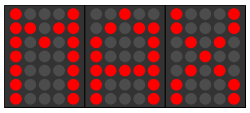
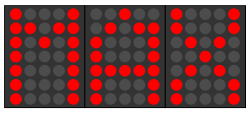
Operating mode	TOL	MEN
Transfer of information from rail line infrastructure	–	✓
Maximum speed supervision	✓	✓
Maximum design speed supervision		✓
Supervision of maximum speed for operating mode [km.h^{-1}]	40	120 / 160
160 km.h^{-1} increased speed mode	–	✓
Maximum speed supervision according to speed commands	–	✓
Supervision of passing beyond signal in STOP position	–	✓
Vigilance supervision	✓	✓
Supervision of safety against spontaneous movement	✓	✓
Notification about enabling signal	–	✓

15.1 Transfer of Information from Rail Line Infrastructure (EVM)

Information transfer from rail line infrastructure in the EVM national mode is carried out by signal sensing, telegram filtration and their decoding to speed commands. During the operation in EVM national mode, the system evaluates only signals with 75 Hz carrying frequency. The presence of 75 Hz carrying frequency in track circuits is detected by the system and indicated on signal repeater of the active cab at indicator **75** NO7.

Information transfer from rail infrastructure is carried out only in the MEN operating mode. In the TOL operating mode information from rail line infrastructure don´t have any effect on the system operation.

Transmitted Telegrams, Speed Commands and their Indication

operation without signal in line part or error indication	Z signal	
evaluation of other conditions	speed command 0	
received telegram 1	speed command 1	
received telegram 2	speed command 2	
received telegram 3	speed command 3	
received telegram 4*	speed command 4	
received telegram 4	speed command 4	

In case of valid speed command 1 a loss of condition signalling „75 Hz available“ means passing beyond signal with STOP aspect, which is evaluated by system like speed command 0.

If train protection isn´t able to evaluate a speed command from signal series at a level, which achieves the level of 75 Hz carrying frequency required for processing, then after a time period of maximum 9 s indication on display vanishes and after another 7 s without information evaluation from rail line an error indication is displayed – Z signal. If the intensity of 75 Hz carrying signal in rail circuits doesn´t achieve level required for processing, system displays symbol of operation without signal in rail line section – Z signal System notifies the driver in both cases by means of an audible signal after travelling 50 m from Z signal display.

Train protection performs in the MEN operating mode within continuous D2 diagnostics a check-up of information transfer from rail line infrastructure. One-time diagnostic check of transfer path for information sensing from rail line infrastructure within D1 diagnostic test is performed by the system in all operating modes.

15.2 Maximum Speed Supervision (EVM)

Train protection compares maximum speed with actual rail vehicle speed. In case of maximum speed violation, the system carries out actions in accordance with operating mode and operating situation.

Maximum speed in a given moment is determined as the lowest one from speeds outlined in table below. Which speeds are included in maximum speed determination, is dependent on operating mode.

	TOL	MEN
maximum design speed	✓	✓
maximum speed for operating mode	✓	✓
maximum speed according to speed command	–	✓

At any max. speed violation in the TOL operating mode, system intervention occurs without any alert, EPV is opened and emergency brake activated. EPV closure is enabled only based on vigilance prompting confirmation after actual DRV speed has dropped under 15 $km.h^{-1}$.

In the MEN operating mode – normal speed mode (more detailed in Section 15.3) when violating maximum speed by more than 2 $km.h^{-1}$ the train protection starts to generate frequent vigilance promptings, which are repeated every 200 m. Latest after travelling 50 metres from maximum speed violation, the system delivers a vigilance prompting. Subsequent 150 metres are available for confirmation. Should confirmation fail to happen, a system intervention and emergency brake activation follow.

Confirmation of third and of subsequent vigilance promptings is accepted by the system only if pressure in the main brake line has dropped under 4,5 bar. Pressure drops in brake line, which is required for confirmation of subsequent vigilance promptings, is indicated on signal repeater by indicator NO1. Detection of required pressure drop is terminated, if the pressure value in the main brake line exceeds 4,8 bar. If the rail vehicle travels with a speed of less than 40 $km.h^{-1}$ with a tolerance of 2 $km.h^{-1}$ and speed command 1 is transmitted, then the pressure drop isn´t required for third and subsequent vigilance promptings.

Increased speed mode is described in Section 15.3.

At any violation of speed command 0 maximum speed (15 $km.h^{-1}$ with tolerance of 2 $km.h^{-1}$), the system intervenes and immediately activates emergency braking.

At maximum design speed violation by more than 7 $km.h^{-1}$, the system intervenes and immediately activates emergency braking.

Without any engaged cabin switch at cabs, any rail vehicle movement is prohibited. Any non-zero vehicle speed is evaluated as maximum speed violation and system intervenes immediately.

Closing of EPV is possible only after the maximum speed violation with zero tolerance has been eliminated.

System evaluates the change of measured speed on DRV axle. In case of excessively high-speed increase, system detects slipping of measured axle. During operation in EVM national mode this function doesn´t in any way influence operating and safety system functionalities.

15.3 160 km.h^{-1} Increased Speed Mode (EVM)

In the increased speed mode, the maximum speed for MEN operating mode is increased to 160 km.h^{-1}. The increased speed mode must be permitted in the system configuration for the specific DRV type. If configuration allows increased speed mode, switching between modes of normal and increased speed occurs automatically in accordance with specification below.

1. if system is in the normal speed mode and rail vehicle speed exceeds 122 km.h^{-1} → system is switched to increased speed mode
2. in case, that system is in increased speed mode and rail vehicle speed drops under 80 km.h^{-1} → system is switched to normal speed mode

Active increased speed mode is indicated on signal repeater by means of indicator NO4.

In the MEN operating mode, in mode of increased speed, when maximum speed is violated by more than 2 km.h^{-1}, the train protection starts to generate frequent vigilance promptings, which are repeated every 180 m. Latest after travelling 30 metres from maximum speed violation, system delivers vigilance prompting and further 150 metres are available for its confirmation. Should confirmation fail to happen, a system intervention and emergency brake activation follow.

Confirmation of second and of subsequent vigilance promptings is accepted by the system only if pressure in the main brake line has dropped under 3,5 bar. Pressure drops in brake line, which is required for confirmation of subsequent vigilance promptings, is indicated on signal repeater by indicator NO1. Detection of required pressure drop is terminated, if the pressure value in the main brake line exceeds 3,7 bar.

Also in the increased speed mode, the maximum design speed of rail vehicle is considered for maximum speed determination.

15.4 Maximum Design Speed Supervision (EVM)

In each operating mode when operating in EVM national mode, the system supervises the maximum rail vehicle design speed. The maximum design speed is dependent on train protection configuration and the train driver hasn´t any option to alter this speed. If the actual maximum design speed of the rail vehicle is greater than 160 $km.h^{-1}$, the design speed considered in maximum speed supervision is decreased to 160 $km.h^{-1}$ in compliance with the extent of MIREL VZ1 train protection system uses according to EVM specification. At any violation of this speed, with a tolerance of +7 $km.h^{-1}$, a system intervention and emergency brake activation occur. Closure of train protection EPV is enabled only after elimination of speed violation.

15.5 Supervision of Maximum Speed for Operating Mode (EVM)

All operating modes according to EVM specification have a defined maximum speed for operating mode. Maximum speed for operating mode is fixed and neither the train driver nor service personnel have any option to alter this speed. Maximum speed values for operating mode are provided on table below.

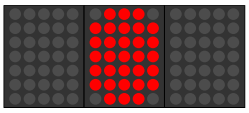
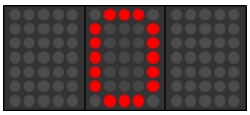
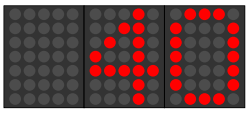
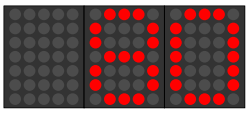
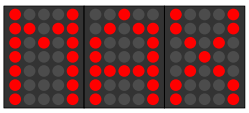
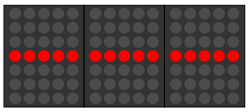
	TOL	MEN
Maximum speed for operating mode	40 km.h^{-1}	120 km.h^{-1} – normal speed mode 160 km.h^{-1} – increased speed mode

At each violation of this speed, with a tolerance of +7 km.h^{-1}, a system intervention and emergency brake activation occur. Closure of train protection EPV is enabled only after elimination of speed violation.

15.6 Maximum Speed Supervision According to Speed Commands (EVM)

When the train protection is in MEN operating mode, the maximum speed supervision is influenced by the speed resulting from transmitted speed commands.

Speed Commands According to EVM Specification

speed command 0		passing beyond signal in STOP position, maximum speed 15 km.h^{-1}
speed command 1		target signal is in STOP position or in position Carefully proceed to call-on signal, maximum speed 15 km.h^{-1}
speed command 2		maximum speed 40 km.h^{-1}
speed command 3		maximum speed 80 km.h^{-1}
speed command 4		maximum speed is highest permitted rail line- or train speed
without signal		operation without signal in rail line part or error indication

15.7 Supervision of Passing Beyond a Signal in STOP Position (EVM)

Supervision of passing beyond a signal in STOP position is an operating function performed by train protection in the MEN operating mode. In case of a valid speed command 1, loss of condition signalizing „available 75 Hz“ means passing beyond a signal with STOP aspect. Such operating situation is evaluated by the system as speed command 0. Transfer of speed command 0 is terminated upon receipt of a speed command enabling higher speed.

In case of speed command 0, any movement of rail vehicle with a speed higher than 15 $km.h^{-1}$, with a tolerance of 2 $km.h^{-1}$, is prohibited. At any violation of this speed, a system intervention and emergency brake activation occur. Closure of train protection EPV is enabled only after elimination of speed violation.

15.8 Vigilance Supervision (EVM)

In all operating modes according to EVM specification, train driver´s vigilance is supervised at a rail vehicle speed over 15 km.h^{-1}. Driver must demonstrate his/her vigilance by confirming vigilance promptings. Train protection delivers vigilance promptings after travelling a distance of 1550 metres. Train protection provides audible vigilance promptings after covering a distance of 1550 meters. Depending on configuration, the system is able to provide in advance a visual vigilance prompting on an external indicator. Distance measurement starts always from the moment of vigilance pedal or pushbutton pressing. Other control elements at driver´s cab can have the vigilance confirmation functionality as well. 150 metres are available for the driver to confirm the vigilance prompting.

In cases, when vigilance pedal or pushbutton is enabled, but subsequent pressing doesn´t occur, the train protection generates vigilance prompting after travelling a distance of 50 metres and driver has 150 m available for confirmation. This function isn´t active with speed violation.

Should confirmation of vigilance prompting not occur, the train protection intervenes and activates the emergency brake. Closing of train protection EPV is carried out after first vigilance confirmation by means of pedal or pushbutton.

15.9 Supervision of Safety against Spontaneous Movement (EVM)

The MIREL VZ1 train protection supervises safety of a motionless rail vehicle against spontaneous movement. Train protection supervises a motionless vehicle as follows:

1. engagement of direct-acting (supplemental, locking) brake (pressure switch),
2. action of automatic brake with pressure in main braking line dropping lower than 4,5 bar (pressure sensor).

Device intervention is terminated by driver by means of operating the vigilance pedal or pushbutton.

After meeting of at least one of mentioned prerequisites, the system considers DRV safety against spontaneous movement to be sufficient. If neither the direct-acting, nor automatic brake is engaged, setting of vehicle into movement is assumed.

Time required for vehicle start is pre-set by system configuration in length of 25 s for DRV in passenger transport and 100 s for DRV in cargo transport. Should the DRV be still motionless 10 s from expiry of stated time, train protection notifies driver about this condition by means of audible ZS20 signal. If the entire pre-set time expires since brake release and DRV start or repeated braking doesn´t materialize, train protection intervenes and activates emergency brake.

System intervention is terminated by driver by means of confirming the vigilance pedal or pushbutton.

15.10 Notification about Speed Command Alteration (EVM)

The aim of notification about alteration of speed commands in EVM national mode is to inform the driver of a rail vehicle at standstill, waiting for signal enabling further travel, about signal- and speed command change.

With a DRV speed lower than 15 $km.h^{-1}$, the train protection responses to a change from speed command prohibiting further travel to a speed command enabling travel with a vigilance prompting. The table below comprises possible situations:

Old Speed Command	New Speed Command
speed command 0	speed command 1
speed command 0	speed command 2
speed command 0	speed command 3
speed command 0	speed command 4
speed command 1	speed command 2
speed command 1	speed command 3
speed command 1	speed command 4

The driver can confirm vigilance prompting by means of operating pedal or pushbutton without any distance and time limitation.

When the signal Z is displayed between the old speed command and new speed command, the system doesn´t deliver vigilance prompting.

16 EVM System Intervention

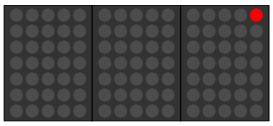
Intervention of train protection according to EVM specification results in emergency brake activation. Opening of train protection EPV occurs after system intervention. Intervention of train protection is accompanied by an abrupt pressure drop in main brake line. Reasons for intervention of train protection and operation restoration after intervention are as described below.

Reason	Method of Operation Restoring
failed vigilance prompting confirmation after 1550 m	operation of vigilance pedal / button
failed vigilance prompting confirmation after speed violation	elimination of speed violation and operation of vigilance pedal / button
missing vehicle safety against spontaneous movement	operation of vigilance pedal / button
vigilance promptings diagnostics	operation of vigilance pedal / button
system diagnostics	feeding voltage disconnection and repeated system start

After intervention termination, the train protection EPV closes and rail vehicle is capable of further operation.

Each train protection intervention is registered.

17 SHP Operating Mode



The MIREL VZ1 train protection operates according to SHP specification in a single operating mode:

Operating Mode	Description
SHP	Operation with full functionality on SHP infrastructure

Selection of operating mode isn´t carried out. By switching the train protection to SHP national mode (described in Section 10), the SHP operating mode is automatically activated.

System operation on operating mode pursuant to SHP specification is indicated on top right corner of the NO11 signal repeater alphanumeric display. Identification of system operating in the SHP national mode is possible on active cab by means of pressing button (NO12) on signal repeater. The text **PL** is displayed on alphanumeric NO11 display with depressed button. After releasing the button, the text **PL** vanishes. During operation in SHP operating mode, as long as the system doesn´t require vigilance confirmation and doesn´t intervene, no other data are displayed on the signal repeater display at the active cab, apart from operating mode indication, as specified above.

After switching of the train protection SHP operating mode, system issues a one-time visual vigilance prompt by lighting up the three-digit alphanumeric display (NO11) on the signal repeater, opens train protection EPV and waits in this condition for confirmation of prompting. The prompting is confirmed by pressing the button (NO14) on the signal repeater. EPV closes after confirmation of vigilance prompting.

Permanent pressing of the vigilance pushbutton doesn´t result in vigilance confirmation. Operating the vigilance pushbutton for a period longer than 1 s results in flashing start of the visual vigilance prompting indication with a frequency of 2,5 Hz. After a time period of 2,5 s, the audible indication of vigilance prompting starts. Subsequently, after another 2 s, the system disconnects the supply to emergency brake EPV and an emergency braking of DRV takes place. Releasing the vigilance pushbutton while the visual and audible prompts are being provided will terminate the execution of this sequence. Releasing the vigilance pushbutton after the emergency braking has been activated does not terminate this sequence[1]. The intervention of the system due to the permanent pressing of the vigilance pushbutton must be terminated in the standard way.

[1]) According to the SHP Functions Integration Technical Description (2038VZ1, version 190313)

18 SHP Operating Functionalities

Operating Mode	SHP
Information Transfer from Rail Line Infrastructure	✓
Cyclical Vigilance Check	✓
One-time vigilance check according to infrastructure	✓
Remote Train Stop	✓
Supervision of Safety Against Spontaneous Movement	✓

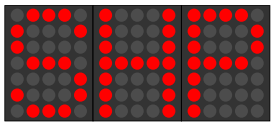
18.1 Information Transfer from Rail Line Infrastructure (SHP)

The SHP train protection system SHP is a point-type train protection. Transfer of information from line infrastructure occurs in the detection extent of DRV passage over a track line point of rail part of the SHP point-type train protection. Information transferred from line part of SHP system is further used for management of vigilance supervision pursuant to SHP specification.

The DRV is usually equipped with a pair of detectors for SHP line infrastructure, which provides for presence scanning of a track point from left or right vehicle side, depending on selected DRV travel direction. The selected DRV travel direction is derived from directional lever position at the active DRV driver cab. If the travel direction is selected, the detector on the right side is active with respect to selected travel direction of the vehicle. If the travel direction is not selected, both detectors are active.[1]

[1] According to the SHP Functions Integration Technical Description (2038VZ1, version 190313)

18.2 One-time vigilance checks according to infrastructure (SHP)



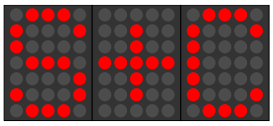
Based on executed detection of passing over a line point of SHP rail infrastructure, the on-board part of SHP system carries out the function of a one-time vigilance supervision and required a defined DRV staff feedback.

In moment of detecting the DRV passage over a line point, the system starts indication of visual vigilance prompting. The MIREL VZ1 train protection carries out the visual indication of passage over a track line point by means of permanent lighting of indicator (NO4)[1] or (NO2)[2] on signal repeater and by means of displaying the text **SHP** on triple-character alphanumeric display of the signal repeater (NO11) of the active driver cab.

If the visual vigilance prompting isn´t confirmed by operating staff within 2,5 s from passage over the track line point, the on-board SHP system continues in its request for visual indication and simultaneously activates audible indication of vigilance prompting. The MIREL VZ1 train protection carries out the audible indication of passage over a track line point by means of audible signal ZS30.

If the audible vigilance prompting isn´t confirmed by operating staff within 4,5 s from passage over the track line point, the MIREL VZ1 system intervenes, opens train protection EPV and activates emergency brake.

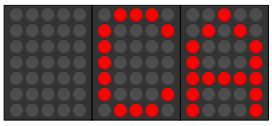
The operating staff must react to the prompting about DRV passage over a line point by pushing and subsequent releasing of vigilance pushbutton. Release of the button must occur within 1 s of pressing. The audible prompting is terminated by vigilance confirmation.



At concurrence of vigilance prompting of the cyclical vigilance supervision (as described in section 18.3) and prompting of the one-time vigilance check upon DRV passage over a track line point, the text **S+C** is indicated on display of the signal repeater (NO11) and the indicator (NO1)[1] or (NO2)[2] flashes and indicator (NO4)[1] lights up. In such case, the cyclical vigilance supervision is confirmed with the first operating of the vigilance pushbutton. After its confirmation, the text **SHP** is displayed on signal repeater display and indicator [1] goes out and indicator [1] or [2] remains permanently lit. By means of second operating of vigilance pushbutton, the one-time vigilance check is confirmed, due to DRV passage over a line point. After confirmation, the display and indicator [1] or [2] on signal repeater goes out.

[1] According to the SHP Functions Integration Technical Description (2038VZ1, version 190313)
[2] According to the SHP Functions Integration Technical Description (2038VZ1, version 151015)

18.3 Cyclical Vigilance Check (SHP)



In the SHP operating mode, the MIREL VZ1 fulfils the function of cyclical vigilance supervision after violation of minimum speed (5 km.h^{-1} or 10% of DRV design speed HDV). Perion of cyclical vigilance check is 60 s.

After expiration of 10 s from moment of cyclical supervision function start, the train protection issues a visual indication of vigilance prompting by means of a flashing indicator ● (NO1)[1] or ● (NO2) [2] on signal repeater, with a frequency of 2,5 Hz. The text **CA** is simultaneously displayed on the triple-character alphanumeric display of the signal repeater (NO11). Any following cyclical vigilance supervision prompting is repeated with a period of 60 s.

If the visual vigilance prompting isn´t confirmed by operating staff within 2,5 s from passage over the track line point, the train protection continues with visual indication and simultaneously activates audible indication of vigilance prompting by means of audible signal ZS30.

If the audible vigilance prompting isn´t confirmed by operating staff within 4,5 s from activation of the visual vigilance prompting, the MIREL VZ1 system intervenes, opens train protection EPV and activates emergency brake.

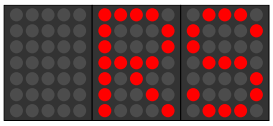
The operating staff must react to the vigilance prompting of train protection by pushing and subsequent releasing of vigilance pushbutton. The visual, as well as audible prompting is terminated by vigilance confirmation.

Time span between two subsequent vigilance promptings is 60 s. If staff presses the vigilance button for a time not exceeding 1 s within this time interval, it demonstrates its vigilance. Time counter between vigilance promptings is hereby set to zero and the 60 s interval is counted from start.

The activity of train protection and the required operating staff feedback in case of cyclical vigilance supervision concurrence with one-time vigilance prompting upon DRV passage over a line point of the rail infrastructure are described in Section 18.2.

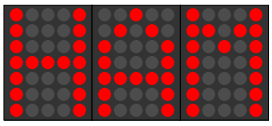
[1] According to the SHP Functions Integration Technical Description (2038VZ1, version 190313)
[2] According to the SHP Functions Integration Technical Description (2038VZ1, version 151015)

18.4 Remote Train Stop (SHP)



Remote train stop is activated by means of cooperating DRV radio station. The radio station decodes the train stop command and delivers requirement towards MIREL VZ1 train protection for system intervention. Based on received requirement, the train protection displays on triple-character alphanumeric display (NO11) of signal repeater the text **RS**, intervenes, opens train protection EPV and activates emergency brake.

18.5 Supervision of Safety against Spontaneous Movement (SHP)



The MIREL VZ1 train protection supervises safety of a motionless rail vehicle against spontaneous movement. Control is carried out only on rail vehicle at standstill. With meeting of at least one of below stated prerequisites, the system considers DRV safety against spontaneous movement to be sufficient. System supervises as follows:

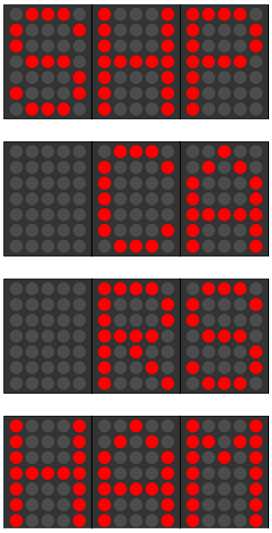
1. engagement of direct-acting (supplemental, locking) brake (pressure switch),
2. action of automatic brake with pressure in main braking line dropping lower than 4,5 bar (pressure sensor).

If neither the direct-acting, nor automatic brake is engaged, setting of vehicle into movement is assumed.

Time required for vehicle start is pre-set by system configuration in length of 25 s for DRV in passenger transport and 100 s for DRV in cargo transport. Should the DRV be still motionless 10 s before expiry of stated time, train protection notifies driver about this condition by means of audible ZS31 signal. If the entire pre-set time expires since brake release and DRV start or repeated braking doesn´t materialize, train protection intervenes, opens EPV and activates emergency brake. Train protection displays the text **HAM** on the triple-character alphanumeric display (NO11) of signal repeater.

19 SHP System Intervention

The reason of train protection intervention in the SHP national mode is the existence of any of events as shown below:



Indication	Reason
SHP	failure to confirm one-time vigilance prompting related with DRV passage over a line point of the SHP rail infrastructure (18.2)
CA	failed cyclical vigilance prompting confirmation (18.3)
RS	remote train stop (18.4)
HAM	missing DRV safety against spontaneous movement (18.5)

Train protection intervention results in emergency brake activation. Train protection EPV is opened upon system intervention. Upon system intervention, the train protection EPV gets opened. The train protection intervention is signalized on NO11 display at signal repeater of the active driver cab by displaying of a text abbreviation, dependent on reason, which has led to emergency braking. The text **S+C** is displayed on the NO11 display in case, if simultaneous intervention due to failure to confirm a one- time and cyclical vigilance prompting.

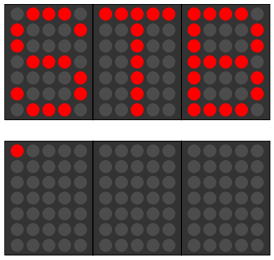
Should reasons leading to intervention persist also after the system intervention, the intervention can´t be terminated. The train driver is notified about this fact by audible and visual indication of train protection, compliant with reason leading to intervention. Intervention can be terminated only after reasons leading to intervention have ceased to exist.

Reasons of SHP- and CA interventions are eliminated by pressing the vigilance button at active driver´s cab. Reasons of RS intervention are eliminated by termination of DRV remote stop command. Reasons of HAM intervention are eliminated by securing the DRV at standstill against spontaneous movement by means of brake engagement. The visual and audible indication of operating intervention reason terminates with the elimination of reasons for operational intervention. The display of the text abbreviation of the operating intervention reason on the NO11 display remains lit permanently.

After elimination of reasons for train protection intervention, the staff can terminate the emergency braking mode by pressing the button (NO14) on signal repeater of the active driver´s cab. After cancelling the emergency braking mode, text displayed on display at active driver´s cab goes out. Emergency brake EPV gets closed and rail vehicle is capable of further operation.

Each train protection intervention is registered.

20 Standby Operating Modes



Standby modes of MIREL VZ1 train protection are intended for cooperation with the ETCS system, for dynamic border passing with change of active train protection on DRV as well as for remote and multiple-element steering of driving rail vehicles or guiding coaches, if the vehicle or driver´s cab isn´t occupied by operating staff. The aim of standby modes is to operate the train protection in condition of readiness for immediate switching to some specific operating mode according to LS-, EVM- or SHP specification.

In standby modes, the train protection doesn´t carry out any operating function or carries out operating functions only in a limited extent.

In standby operating modes, the train protection carries out all system safety functions in full extent in such a way, that the ability for instantaneous switching to active operating mode isn´t limited.

The MIREL VZ1 train protection has implemented following standby operating modes:

Operating mode	Operating Mode Purpose
STB-N	standby mode without vigilance supervision
STB-LS	standby mode with vigilance supervision according to LS specification or vigilance supervision according to TSI specification and remote stop option
STB-EVM	standby mode with vigilance supervision according to EVM specification or vigilance supervision according to TSI specification
STB-SHP	standby mode with vigilance supervision according to SHP specification or vigilance supervision according to TSI specification and remote stop option

The selection of standby operating modes and switching between standby and active operating mode isn´t carried out by DRV staff within the control of MIREL VZ1 train protection. Switching of standby modes is implemented automatically, in cooperation with the ETCS system or automatically in cooperation with DRV technology. Switching of standby operating modes can´t be carried out by means of signal repeater.

When MIREL VZ1 train protection cooperates with the ETCS system, the selection of standby operating modes of MIREL VZ1 train protection is controlled by cooperating ETCS system by means of MIREL STB gateway. DRV staff follows ETCS system operating manual.

In case of dynamic border passing, remote or multiple-element steering, the selection of MIREL VZ1 train protection standby modes are carried out directly by steering controllers of DRV functional statuses, or eventually in cooperation with DRV control system. DRV staff follows the rail vehicle operating manual instructions. If system intervenes, switching to a standby mode isn´t possible by means of selector serving for switching DRV functional statuses.

When switching from standby operating mode to an active operating mode at operation in the LS national mode, the POS operating mode is automatically activated with a motionless DRV and at a non-zero speed of DRV, the PRE operating mode is automatically activated.

When switching from standby operating mode to an active operating mode at operation in the EVM national mode, the TOL operating mode is automatically activated with a motionless DRV and at a non-zero speed of DRV, the MEN operating mode is automatically activated.

Switching of train protection to a standby mode is indicated on signal repeater at active driver´s cab by displaying **STB** on display (NO11). **STB** text on display goes out after time of 5 seconds from activation of standby operating mode, and the standby operating mode remains indicated by a red dot in the upper left corner of the NO11 display.

When operating the train protection in a standby operating mode, the staff can carry out a verification of mentioned status by pressing any of buttons on signal repeater of active driver´s cab. **STB** text is displayed on display for a time of 5 seconds after pressing the button.

20.1 STB-N – Standby Operating Mode without Vigilance Supervision

The STB-N standby mode is intended for DRV operation on territory of states, which national modes and national infrastructures aren´t supported by MIREL VZ1 train protection. DRV travel is ensured by a different national train protection on-board system, which is active on DRV.

The STB-N standby mode is also intended for DRV operation on territory of Czech, Slovakia, Hungary and Poland in configuration of remote and multiple-element rail vehicle steering, when the specific DRV or GC isn´t occupied by driving staff. HDV drive is ensured by a train protection on-board system, which is active on DRV occupied by driving staff.

Information Transfer from Rail Line Infrastructure

Isn´t carried out in the STB-N operating mode.

Vigilance Supervision

Isn´t carried out in the STB-N operating mode.

Maximum Speed Supervision

Isn´t carried out in the STB-N operating mode.

Supervision of Accord Between Actual and Selected Travel Direction

Isn´t carried out in the STB-N operating mode.

Remote Stop

Isn´t carried out in the STB-N operating mode.

Supervision of Safety against Spontaneous Movement

Isn´t carried out in the STB-N operating mode.

20.2 STB-LS – Standby Operating Mode with LS Vigilance Supervision

The STB-LS standby operating mode implements standby status of the MIREL VZ1 train protection when operating a DRV on territory of Czech and Slovakia on railway lines equipped with ETCS line infrastructure and with operation of MIREL VZ1 train protection as national STM module of LS ETCS system.

Transition to STB-LS operating mode and return transition to any other operating mode of MIREL VZ1 operating mode is controlled automatically by MIREL STB functional gateway. Transition to STB-LS operating mode can´t be carried out by means of signal repeater.

Beyond the framework of standard standby mode indication (Section 20), the STB-LS operating mode is indicated by indicator ● (NO5) in compliance with indication rules for vigilance supervision functionality (Section 12.12 and Section 21.1 respectively).

Information Transfer from Rail Line Infrastructure

Isn´t carried out in the STB-LS operating mode.

Vigilance Supervision

In the STB-LS operating mode, the train driver has the duty to demonstrate his/her vigilance in the same way like in the PRE operating mode when operating without transfer of information from rail line infrastructure. System requires cyclical vigilance supervision in a way as outlined in Section 12.13. Depending on system configuration, in the STB-LS mode, the vigilance supervision pursuant the LS specification can be replaced by vigilance supervision pursuant specification TSI LOC&PAS 1302/2014 and UIC 641 described in Section 21.1.

Should the train driver fail to confirm the provided vigilance prompting by pressing the vigilance button or, eventually, pedal, system intervention takes place (NZ1) as well as emergency brake activation. Intervention process and termination is carried out with a procedure outlined in Section 13 and Section 22 respectively.

Maximum Speed Supervision

Isn´t carried out in the STB-LS operating mode.

Supervision of Accord Between Actual and Selected Travel Direction

Isn´t carried out in the STB-LS operating mode.

Remote Stop

In the STB-LS operating mode, the remote stop functionality is active, if enabled by the MIREL VZ1 train protection configuration, if allowed by organizational provision of user and the radio station must be equipped with corresponding functionality. Function is outlined in Section 12.18.

Upon detection of remote stop command, system intervention (NZ4) takes place, as well as emergency brake activation. Process and termination of intervention are carried out with a procedure outlined in Section 13.

Supervision of Safety against Spontaneous Movement

Isn´t carried out in the STB-LS operating mode.

20.3 STB-EVM – Standby Operating Mode with EVM Vigilance Supervision

The STB-EVM standby operating mode implements standby status of the MIREL VZ1 train protection when operating a DRV on territory of Hungary on rail lines equipped with ETCS line infrastructure and with operation of MIREL VZ1 train protection as national STM module of EVM ETCS system.

Transition to STB-EVM operating mode and return transition to any other operating mode of MIREL VZ1 operating mode is controlled automatically by MIREL STB functional gateway. Transition to STB-EVM operating mode can´t be carried out by means of signal repeater.

Beyond the framework of standard standby mode indication (Section 20), the STB-EVM operating mode is indicated by permanently lit indicator **M** (NO9).

Information Transfer from Rail Line Infrastructure

Isn´t carried out in the STB-EVM operating mode.

Vigilance Supervision

In the STB-EVM operating mode, the train driver has the duty to demonstrate his/her vigilance in the same way like in the MEN operating mode. System requires cyclical vigilance supervision in a way as outlined in Section 15.8. Depending on system configuration, in the STB-EVM mode, the vigilance supervision pursuant the EVM specification can be replaced by vigilance supervision pursuant specification TSI LOC&PAS 1302/2014 and UIC 641 described in Section 21.1.

Should the train driver fail to confirm the provided vigilance prompting in prescribed way, system intervention takes place as well as emergency brake activation. Intervention process and termination is carried out with a procedure outlined in Section 16 and Section 22 respectively.

Maximum Speed Supervision

Isn´t carried out in the STB-EVM operating mode.

Supervision of Accord Between Actual and Selected Travel Direction

Isn´t carried out in the STB-EVM operating mode.

Remote Stop

Isn´t carried out in the STB-EVM operating mode.

Supervision of Safety against Spontaneous Movement

Isn´t carried out in the STB-EVM operating mode.

20.4 STB-SHP – Standby operating mode with SHP vigilance supervision

The STB-SHP standby operating mode carries out the standby status of MIREL VZ1 train protection when operating a DRV on the territory of Poland on track lines equipped with ETCS line infrastructure during operation of MIREL VZ1 train protection as a national STM module of SHP type of ETCS system.

Switch to STB-SHP operating mode as well as return switch to any other operating mode of MIREL VZ1 train protection is controlled by automatic function gateway MIREL STB. Switch over to STB-SHP operating mode can´t be carried out by means of signal repeater.

Beyond the framework of the standard indication of standby mode (Section 20), the STB-SHP operating mode is indicated by permanently lit point in the right top corner of the alphanumeric display on signal repeater NO11.

Transfer of Information from Line Infrastructure

Isn´t carried out in the STB-SHP mode.

Vigilance Supervision

In the STB-SHP operating mode, the driver has the obligation to demonstrate his vigilance identically like with the SHP operating mode. System requires cyclical vigilance supervision in a way like described in Section 18.3. Depending on system configuration, in the STB-SHP mode, the vigilance supervision pursuant the SHP specification can be replaced by vigilance supervision pursuant specification TSI LOC&PAS 1302/2014 and UIC 641 described in Section 21.1.

If the driver doesn´t confirm the issued vigilance prompting in a defined way, a system intervention takes place, as well as emergency brake activation. The course and termination of intervention are carried out with a procedure as provided in Section19 and Section 22 respectively.

Maximum speed supervision

Isn´t carried out in the STB-SHP mode.

Accord Between Actual and Selected Travel Direction

Isn´t carried out in the STB-SHP mode.

Remote Stop

In the STB-SHP operating mode, the remote stop function is operating, if enabled by configuration of MIREL VZ1 train protection, if allowed by organizational measures of Operator and if the radio station is equipped with the respective function. Function is described in Section 18.4.

Upon detection of command for a remote stop, a system intervention takes place, as well as emergency brake activation. The course and termination of intervention are carried out with a procedure as provided in Section 19.

Inspection of Safeguarding against Spontaneous Movement

Isn´t carried out in the STB-SHP mode.

21 TSI operating functionalities

Operating Mode	STB-N	STB-LS	STB-EVM	STB-SHP
Vigilance Supervision	–	✓	✓	✓

21.1 Vigilance Supervision (TSI)

The train protection performs the driver´s vigilance supervision by means of providing visual and audible vigilance promptings, which have to be confirmed by driver by means of vigilance pushbuttons, pedals or controllers.

Vigilance can be confirmed by means of pushbutton or pedal only if the cabin switch has been engaged at the respective cab. Use of vigilance pedals can be disabled by system configuration.

Vigilance pushbutton or pedal must be operated at least for 50 ms. Permanent pushing down of a button or pedal doesn´t result in repeated vigilance confirmation.

Some steering controllers at rail vehicle cab can be connected to vigilance confirmation circuits as well. Usually this applies for steering controller and braking device. By means of steering controllers, vigilance can be confirmed only at active driver´s cab. Specific connection of individual steering controllers at driver´s cab to train protection circuits depends on rail vehicle type.

When confirming vigilance by manipulating with steering controllers, the minimum time period of 50 ms must be adhered to when passing through positions of such controllers, which are not arrested.

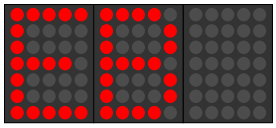
In case of duty to confirm vigilance on the signal repeater, the indicator ● (NO5) goes out. If the driver hasn´t duty to confirm his/her vigilance, the indicator ● (NO5) is lit on signal repeater. If indicator ● isn´t lit, the driver can confirm vigilance. In case, when driver presses the vigilance button or pedal with a lit indicator ●, this confirmation is not accepted.

Vigilance cycle length is based on fixed time interval that is given by the system configuration in range of 5-60 s and does not depend on actual DRV speed. Cyclical vigilance supervision is performed in STB-LS, STV-EVM a STB-SHP operating modes at DRV speed higher than 5 km. h^{-1}.

Within this interval, first 1 s the indicator ● is lit and vigilance can´t be confirmed. 2 s before the end of vigilance interval, the system provides driver at active cab with visual vigilance prompting - the indicator ● (NO5) flashes. The train driver must confirm the vigilance prompting in the above-mentioned way. If this doesn´t happen until the end of vigilance interval, the system provides an audible vigilance prompting – acoustic signal ZS1. The length of audible ZS1 vigilance prompting is 3,5 s, during which vigilance can be confirmed.

An eventual visual and audible prompting is terminated with vigilance confirmation and indicator ● is lit. With vigilance confirmation, the interval starts to run from the beginning. If vigilance is not confirmed within 3,5 s of the audible prompting, the system intervenes and activates emergency brake. Each vigilance prompting must be confirmed.

22 TSI system intervention



Train protection intervention results in emergency brake activation. Train protection opens EPV after system intervention.

Train protection intervention is signalled on NO11 display on signal repeater of active cab by means of letters **EB**.

Termination of operational intervention is possible only after vigilance confirmation by DRV operator. By confirmation of vigilance, audible and visual indication is terminated. After confirmation of vigilance, train operator can terminate emergency braking mode by pressing the pushbutton (NO14) on signal repeater of active cab. After cancelling the emergency stop mode, **EB✓**appears on NO11 display of active signal repeater. After intervention termination, the train protection EPV closes, and rail vehicle is capable of further operation.

23 System Functionalities

Operating functionalities, which are carried out by the system in all operating modes and which are common for operation in all national modes, are as follows:

- D1 one-time system diagnostics
- D2 continuous system diagnostics
- measurement of DRV actual speed
- measurement of travelled distance
- travel direction evaluation
- pressure measurement in the main brake line
- entering of operating data
- audible system signalization
- indication of DRV zero speed
- regulation of indication elements illumination intensity on signal repeater

24 Entering of Operating Data

Entering of operating data is enabled only on active driver´s cab of train protection. Staff has available a triple-character alphanumeric display (NO11) and buttons , and (NO12, NO13, NO14). No train protection data can be altered by staff on the signal repeater at the inactive driver´s cab and on central unit.

The signal repeater at active driver´s cab displays current maximum speed when in basic condition during operation in LS national mode. When operating in EVM national mode, the signal repeater displays in basic condition the respective speed command. When operating in SHP national mode, the signal repeater doesn´t display in basic condition any data. In case of staff action on triple-button keyboard, the signal repeater gets switched from basic condition to menu and staff can enter operating parameters:

- switch between national modes
- switch operating mode (only in LS and EVM national mode)
- set prescribed speed (only in LS national mode)

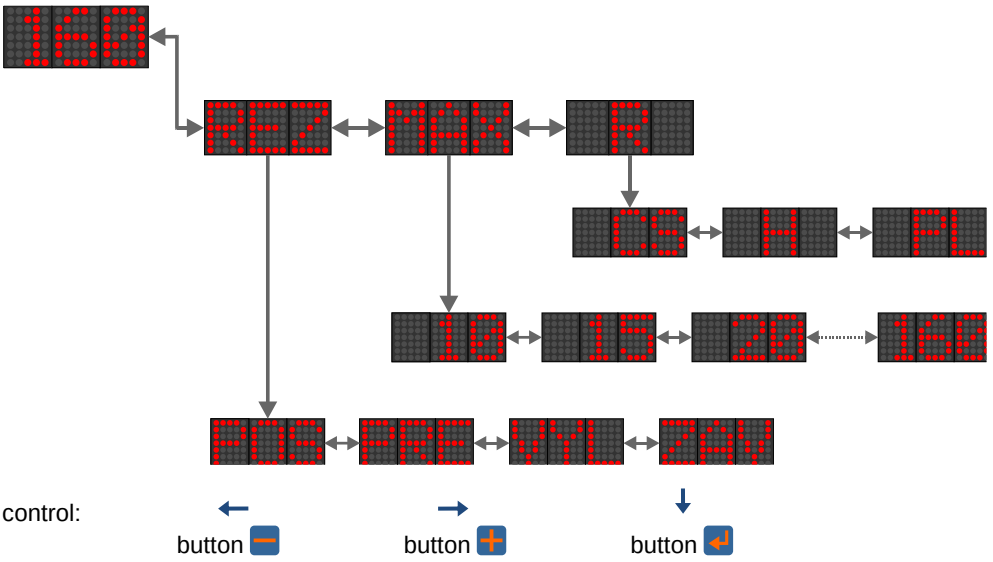
When entering operating parameters, the staff has the duty to follow procedure below:

- select the operating parameter to be modified
- in the mode of slowly flashing display, set by means of buttons and the new parameter value
- after setting the new value, confirm its change by pressing button
- verify, if the operating parameter value is displayed in compliance with required change after lighting-up of the entire display

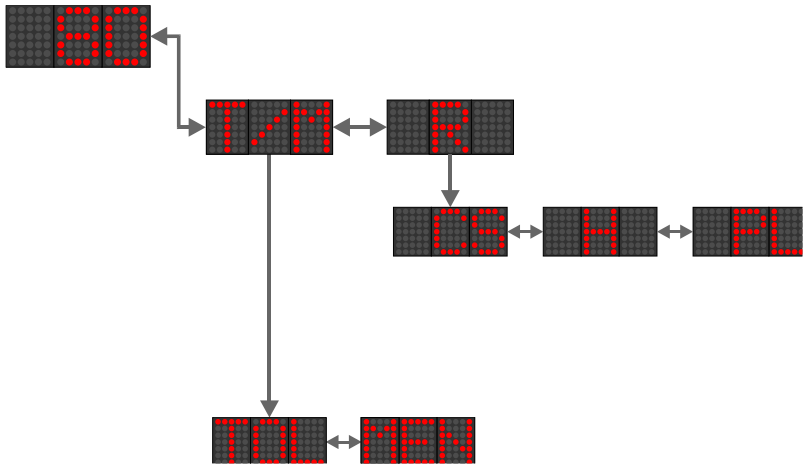
Should the central unit fail to accept the required change, modification of operating data didn´t take place! Option to change is indicated by slowly flashing display. After change accomplishment, the new figure must be confirmed by button . After confirmation of new value, display stops to flash and after a period of 5 s switches automatically to basic condition.

If no pushbutton is operated within a time of 5 s, with signal repeater in data entering menu, the signal repeater gets automatically switched to basic condition. The process of data entering into system is disabled and is immediately interrupted in case of train protection intervention and upon system error detection.

Entering of operating parameters when operating in LS national mode is enabled only at zero speed of DRV. Below shown menu of signal repeater serves for entering:

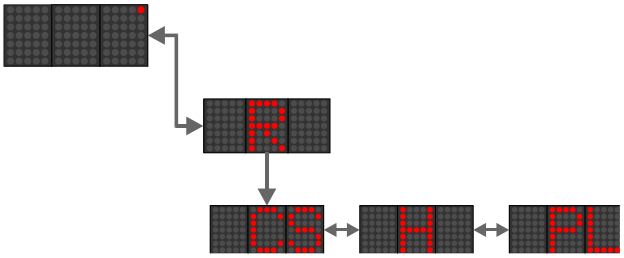


The selection of operating mode when operating in EVM national mode can be carried out at a DRV speed lower than 40 km.h^{-1}, without actual speed violation. Switching between national modes is possible only on DRV at standstill. Menu shown below serves for entering of operating parameters during operation in EVM national mode:



control: button button button

When operating in SHP national mode, it is possible to carry out only switching between national modes. Switching is enabled only on DRV at standstill. Menu shown below serves for switching between national modes during operation in SHP national mode:

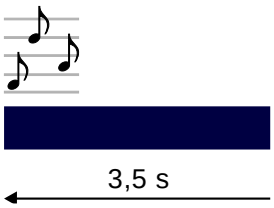
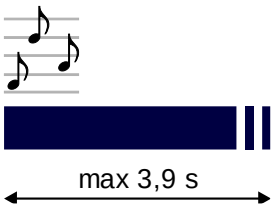
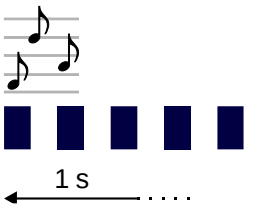
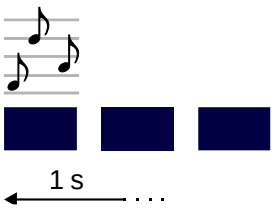
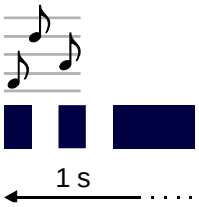


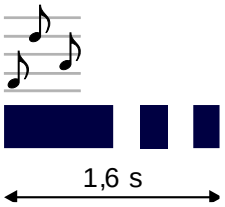
control: button button button

25 Audible Signalling

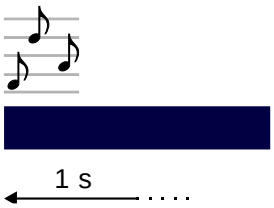
Each rail vehicle driver´s cab is equipped with train protection horn, which warns the driver about duty to carry out control action, or notifies him/her about subsequent actions by train protection. Horn is available in two design options, as a separate device, or a device to be fitted into control panel.

Audible signalling during operation in LS national mode:

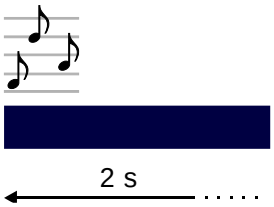
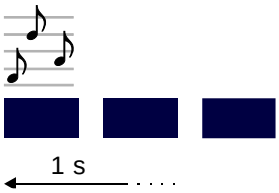
ZS1 	**Standard vigilance prompting**	
	start	3,5 s before expiry of vigilance control interval, or at start of braking curve modelling
	termination	upon vigilance confirmation
	type	permanent horn tone without fade-out
ZS1B 	**One-time vigilance prompting**	
	start	at calculated moment of braking curve modelling
	termination	0,4 s after vigilance confirmation
	type	permanent horn tone with 2 fade-outs
ZS2 	**Maximum speed violation**	
	start	upon maximum speed violation with respective tolerance (as a rule, more than 5 $km.h^{-1}$)
	termination	upon speed decrease under limit maximum speed + tolerance (train protection intervention due to maximum speed violation isn´t a reason to terminate signalling of maximum speed violation)
	type	fast interrupted horn tone 2,5 Hz with 1:1 buzz ratio
ZS3 	**Discrepancy between selected and actual direction, failed safety against spontaneous movement**	
	start	after travelling a distance of 6 m in prohibited direction, 10 s before time interval expiry for start of DRV movement
	termination	after travelling a distance of 10 m in prohibited direction and train protection intervention or upon achieving accord of travel direction with selected one, after train protection intervention or after securing DRV against movement
	type	slow interrupted horn tone 1,25 Hz with 3:1 buzz ratio
ZS4 	**Remote train stop via radio station**	
	start	after receiving dispatcher command for emergency stop by means of radio station
	termination	after termination of dispatcher command for emergency stop at zero DRV speed
	type	interrupted horn tone with motive 2 pulses (2,5 Hz, 1:1 buzz ratio) 1 pulse (1,25 Hz, 3:1 buzz ratio)

ZS7 	**Notification about enabling signal**	
	start	in case of enabling signal transfer
	termination	one-time signal
	type	audible signal aspect with motive 1 pulse (0,7 s) 2 pulses (0,1 s)
ZS8 	**Notification about unrequested vigilance confirmation**	
	start	after pressing vigilance button when blue light is lit
	termination	one-time signal
	type	audible signal aspect with motive 1 pulse (0,2 s)

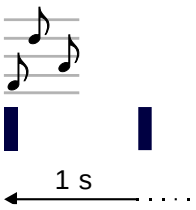
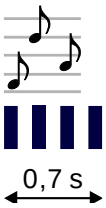
Audible signalling during operation in EVM national mode:

ZS20 	**Vigilance prompting**	
	start	in various operating situations, device prompting for vigilance confirmation
	termination	Upon driver´s vigilance confirmation, after expiry of interval, which is usually dependent on travelled distance
	type	permanent horn tone

Audible signalling during operation in SHP national mode:

ZS30 	**Standard vigilance prompting**	
	start	specified time before end of prompting to confirm vigilance
	termination	upon vigilance confirmation
	type	permanent horn tone without fade-out
ZS31 	**Missing Safety against Spontaneous Movement**	
	start	10 s before end of time interval for DRV setting into motion
	termination	upon train protection intervention or after securing DRV against movement
	type	slow interrupted horn tone 1,25 Hz with 3:1 buzz ratio

Audible signalling common for all national modes:

ZS10		**Notification about repeated D1 execution**	
		start	15 s before automatic repeated start-up of D1 diagnostic test
		termination	upon start of D1 diagnostics, by postponing the D1 diagnostics execution for additional 15 minutes t
		type	short slow interrupted horn tone 1 Hz with 1:9 buzz ratio
ZS11		**Start of D1 diagnostics**	
		start	upon putting system into operation, after repeated D1 start
		termination	one-time signal
		type	4 brief pulses (0,1 s)

26 Zero Speed Indication

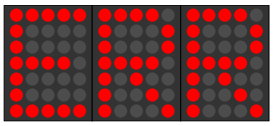
Indication element (NO10) has red colour and is located on front panel of signal repeater. Its function is:

- rail vehicle zero speed indication – permanent lighting
- indication of braking curve modelling in PRE operating mode - flashing

When the rail vehicle has a zero speed, the indication element is permanently lit. In the moment of rail vehicle start, the indicator goes out, whereby indicating to staff the functionality of speed sensing, distance, acceleration and direction block unit. When the zero-speed indicator remains permanently lit with rail vehicle in motion, there is a train protection error present and its further operation isn´t allowed.

Under operation in LS national mode, if the indicator is permanently lit, staff can perform alteration of entered data. Under operation in EVM national mode, the mentioned activities aren´t conditioned with zero speed of DRV. In any situation, zero speed is required for switching of national modes, which is indicated with a lit indicator .

27 Error Signalling



Train protection errors are divided into two groups. Errors disabling further train protection operation and errors limiting further train protection operation. Upon detection of an error disabling further operation, the system switches itself automatically to a safe condition by means of opening train protection EPV and activating emergency brake. Indicator **ERR** (ZJ8) gets lit on the front panel of central unit. After emerging of any error, the staff shall re-initialize the train protection by disconnecting the train protection circuit breaker for a time of at least 5 seconds and subsequent switch-on. Should the breakdown be indicated repeatedly, rail vehicle staff doesn´t carry out any further actions to its remedy.

After system re-initializing, the fact should be considered, that the system runs-up with preselected operating parameters.

In order to find out the precise reason of system error, numerical system error code indicating error is displayed after pressing the signal repeater button (NO14) at active driver´s cab. List of errors, which are detected by the system within the framework of diagnostic tests, is provided in two tables below. Each table is linked to the relevant version of the technical conditions of MIREL VZ1.

List of errors excluding further operation of train protection system, which are linked to technical conditions of MIREL VZ1 in version 211203 (257VZ1)	
E00	permanent loss of communication between signal repeater main module and central unit
E01	error detected by monitoring WD-type circuits of central unit
E02	EEPROM memory error of central unit
E03	combined error of signal repeater main module at active driver´s cab
E04	communication error between central unit and signal repeater main module at 1st driver´s cab
E05	communication error between central unit and signal repeater main module at 2nd driver´s cab
E06	communication error between M- and C- channels of central unit
E07	error of code-sensing transfer path detected by one-time D1 diagnostics
E08	EPV error detected by one-time D1 diagnostics
E09	non-execution error of D1 diagnostic test within 4 hours after switch-on of system
E10	intervention integrity error of processor modules in central unit
E11	EPV error upon intervention of train protection – insufficient pressure drop in main brake line
E12	DRV movement with insufficient pressure in main brake line
E14	error of maximum speed evaluation integrity
E15	error of evaluation integrity regarding transmitted signal aspect according to LS specification or speed command according to EVM specification
E17	start-up error of central unit processor modules
E18	start-up error of signal repeater main module at active driver´s cab
E19	start-up error of signal repeater control module at active driver´s cab
E20	measurement error of actual speed
E21	evaluation error of actual travel direction
E22	powering error of incremental speed sensor
E23	powering error of pressure sensor in main line
E24	pressure measurement error in main line
E25	actual speed integrity error between M- and C- channels
E26	pressure integrity error in main line between M- and C- channels
E27	integrity error of pre-set operating mode between M- and C- channels
E28	integrity error of required operating mode – requirement for prohibited operating mode
E30	error of decoding and processor instruction execution of central unit
E31	integrity error of set operating parameters

E32	error of repeated D1 diagnostic test start-up
E33	integrity error of train protection configuration data
E34	integrity error of configuration data between M- and C- channels
E35	validity error of D4 diagnostic test
E36	error of system real time setting
E40	central unit FLASH memory error
E41	central unit RAM memory error
E42	software integrity error – UNI section
E43	software integrity error – LS section
E44	software integrity error – EVM section
E45	software integrity error – SHP section
E46	software integrity error – STB section
E50	combined error of signal repeater control module at active driver´s cab
E51	error of central unit communication with signal repeater control module at active driver´s cab
E52	signal aspect indication integrity error on signal repeater at active driver´s cab
E53	functional error of  signal repeater button at active driver´s cab
E54	functional error of  signal repeater button at active driver´s cab
E55	functional error of  signal repeater button at active driver´s cab
E56	error of unrequired termination of system intervention
E60	combined error of STBM or STBC blocks of MIREL STB gateway
E61	integrity loss of active MIREL STB gateway mode and operating mode of MIREL VZ1 system
E62	loss of STM_CMD command integrity for MIREL VZ1 system between the M and C channels of MIREL STB gateway
E63	communication error between MIREL STB gateway with MIREL VZ1 system
E64	communication error between MIREL STB gateway with ETCS system
E65	integrity loss of command from ETCS or VCS
E66	integrity loss of generated safety-relevant messages between M and C channels of MIREL STB gateway
E67	integrity loss of MIREL STB binary outputs
E68	combined error of STBGW block of MIREL STB gateway
E69	communication error between M- and C- channels of MIREL STB gateway
E70	communication error with STBGW block of MIREL STB gateway
E71	integrity error of configuration parameters from STBGW block
E72	integrity loss of state two MIREL STB gateways in function master/slave
E73	communication error between gateways MIREL STB master and slave
E74	error of external communication interface including the master/slave function
E80	communication error of central unit with M-channel of MIREL STB gateway
E81	communication error of central unit with C-channel of MIREL STB gateway
E82	integrity error of standby mode control binary inputs
E83	combined error of recording unit
E84	integrity error of binary interface with SHP system
E85	communication error of central unit with M-channel of MIREL SHPE generator
E86	communication error of central unit with C-channel of MIREL SHPE generator
E90	combined error of MIREL SHPE generator
E91	integrity error between M- and C- channels of MIREL SHPE generator
E92	communication error of MIREL SHPE generator
E93	antenna error of MIREL SHPE generator

List of errors excluding further operation of train protection system, which are linked to technical conditions of MIREL VZ1 in version 200401 (257VZ1)	
E00	permanent loss of communication between signal repeater main module and central unit
E01	error detected by monitoring WD-type circuits of the central unit
E02	EEPROM memory error of the central unit
E03	combined error of signal repeater main module at active driver´s cab
E04	communication error between central unit and signal repeater main module at 1st driver´s cab
E05	communication error between central unit and signal repeater main module at 2nd driver´s cab
E06	communication error of processor modules in central unit
E07	error of code-sensing transfer path detected by one-time D1 diagnostics
E08	EPV error detected by one-time D1 diagnostics
E09	non-execution error of D1 diagnostic test within 4 hours after switch-on of the system
E10	intervention integrity error of processor modules in central unit
E11	EPV error upon intervention of train protection – insufficient pressure drop in main brake line
E12	DRV movement with insufficient pressure in main brake line
E14	error of maximum speed evaluation integrity
E15	error of evaluation integrity regarding transmitted signal aspect according to LS specification or speed command according to EVM specification
E17	start-up error of central unit processor modules
E18	start-up error of signal repeater main module at active driver´s cab
E19	start-up error of signal repeater control module at active driver´s cab
E20	measurement error of actual speed
E21	evaluation error of the actual travel direction
E22	powering error of incremental speed sensor
E23	powering error of pressure sensor in main line
E24	pressure measurement error in the main line
E25	actual speed integrity error between M- and C- channels
E26	pressure integrity error in the main line between M- and C- channels
E27	integrity error of pre-set operating mode between M- and C- channels
E28	integrity error of the required operating mode – requirement for prohibited operating mode
E30	error of decoding and processor instruction execution
E31	integrity error of set operating parameters
E32	error of repeated D1 diagnostic test start-up
E33	integrity error of train protection configuration data
E34	integrity error of configuration data between M- and C- channels
E35	validity error of D4 diagnostic test
E36	error of system real time setting
E40	central unit FLASH memory error
E41	central unit RAM memory error
E42	software integrity error – UNI section
E43	software integrity error – LS section
E44	software integrity error – EVM section
E45	software integrity error – SHP section
E46	software integrity error – STB section
E50	combined error of signal repeater control module at active driver´s cab
E51	error of communication with signal repeater control module at active driver´s cab
E52	signal aspect indication integrity error on signal repeater at active driver´s cab

E53	functional error of  signal repeater button at active driver´s cab
E54	functional error of  signal repeater button at active driver´s cab
E55	functional error of  signal repeater button at active driver´s cab
E56	error of unrequired termination of system intervention
E60	combined MIREL STB gateway error – M-channel
E61	integrity error of required operating mode by MIREL STB gateway – channel M and actual operating mode of MIREL VZ1 system
E62	integrity error of required operating mode between M- and C-channel of MIREL STB gateway, detected by channel M
E63	combined communication error of MIREL STB gateway – channel M
E64	communication error of MIREL STB gateway – channel M with ETCS system
E65	combined error of ETCS system command, detected by MIREL STB gateway – channel M
E70	combined error of MIREL STB gateway – channel C
E71	integrity error of required operating mode by MIREL STB gateway – channel C and actual operating mode of MIREL VZ1 system
E72	integrity error of required operating mode between M- and C-channel of MIREL STB gateway, detected by channel M
E73	combined communication error of MIREL STB gateway – channel C
E74	communication error of MIREL STB gateway – channel C with ETCS system
E75	combined error of ETCS system command, detected by MIREL STB gateway – channel MC
E80	communication error with MIREL STB gateway – channel M, detected by MIREL VZ1 system
E81	communication error with MIREL STB gateway – channel C, detected by MIREL VZ1 system
E82	integrity error of standby mode control binary inputs
E83	combined error of recording unit
E84	binary integrity error of interface with SHP system
E85	error of communication with MIREL SHPE generator – M-channel, detected by MIREL VZ1 system
E86	error of communication with MIREL SHPE generator – C-channel, detected by MIREL VZ1 system
E90	combined error of MIREL SHPE generator – M-channel
E91	integrity error between M and C channels of MIREL SHPE generator – M-channel
E92	error of communication of MIREL SHPE generator – M-channel
E93	antenna error of MIREL SHPE generator – M-channel
E95	combined error of MIREL SHPE generator – C-channel
E96	integrity error between M and C channels of MIREL SHPE generator - C-channel
E97	communication error of MIREL SHPE generator – C-channel
E98	antenna error of MIREL SHPE generator – C-channel

Upon emerging of an error limiting further operation, neither the EPV isn´t opened, nor emergency brake activated. There isn´t any error indicated on central unit front panel and signal repeater at active driver´s cab. These are errors of signal repeater at inactive driver´s cab. Such errors limit the train protection operation to the specific driver´s cab which operates without any error.

All errors detected during operation in ZAV operating mode when moving in travel, are classified as errors limiting further system operation. After rail vehicle stopping, these errors are re-classified dependent on error type to errors disabling further operation. Opening of EPV due to error detection occurs in ZAV operating mode only after DRV coming to a standstill.

Errors limiting further operation of train protection system, indicated on signal repeater of inactive driver's cab	
E00	combined error of signal repeater main module at active driver´s cab

28 Notes