INSTALLATION OF NEW SYSTEMS
FOR THE ICE MAINTENANCE FLOOR IN BERLIN-RUMMELSBURG, GERMANY

English

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Installation of new systems for the ICE maintenance floor in Berlin-Rummelsburg

The ICE maintenance floor at Rummelsburg in Berlin is being expanded to provide maintenance for the new generation of ICE trainsets. In the first stage of construction, Rail Power Systems (RPS) replaced the existing automatic disconnection and earthing system for the five indoor tracks with a new, modern control system. This uses a new transponder system instead of the previously standard key switches for controlling the installation.

Figure 1: Interior view of the hall

Until the end of 2022, DB Fernverkehr AG will be expanding the ICE maintenance floor Rummelsburg II for maintenance of the ICE 4. In the first stage of expansion, various alterations and modifications were made. Among other things, the roof maintenance platforms and the overhead contact line system were replaced. In the second stage of expansion in 2020/21, the vehicle hall

Table 1: Implementing the five safety rules

Safety rules	Implementation
Disconnect completely	Open the overhead contact line disconnector switch
Secure against re-connection	Interrupt the control circuit
Verify absence of operating voltage	Measurement using a voltage transformer
Carry out earthing and short-circuiting	Switch on the earthing switches at both ends of the segment (connect to return conductor)
Provide protection against adjacent live parts	Work area fenced off, doors locked, access only possible in safe state

will be extended to around 420 m and the newly delivered automatic disconnection and earthing system will also be expanded.

The new automatic disconnection and earthing system fulfils its purpose of protecting the safety of people, ensuring hazard-free work on the roof maintenance platforms. It has been assessed by external experts as suitable for SIL2 applications.

The control system for energising the overhead contact line, for the disconnection and for the earthing is provided by what is known as an automatic disconnection and earthing system (ADES). Operating in conjunction with other facilities on the roof maintenance structure, it ultimately ensures compliance with the five safety rules (Table 1). Unlike previous system designs, the ADES for the Berlin-Rummelsburg maintenance hall has been fitted with a transponder system for identification and operation by authorised persons. Compared to previously standard key-operated systems, the advantage of this transponder system is that users can log in and out at different terminals, significantly reducing the distances maintenance personnel have to walk back and forth and therefore saving time.

As the ADES is intended to be used multiple times during the course of a working day, it differs significantly in its use from the overhead contact line voltage testing equipment used in tunnels, for example. This latter type of voltage testing equipment is only used for test purposes during its service life, except when needed due to an accident. For this reason, a specific requirements class was defined for the ADES, and a Safety Integrated Level (SIL) in accordance with EN 61508 [2] was then derived for this to be taken into account and implemented in the course of the project.

The overhead contact line for the indoor tracks is designed as a live rail overhead contact line and it has a switching group for each track.

The ADES controls and monitors the overhead contact line and earthing switches, the EI6 signals (stop for vehicles with raised pantograph) and the doors of the roof maintenance platform. The system state is monitored by sensors, voltage transformers and current transformers. The way that vehicle maintenance is performed requires maintenance work to be carried out on roof maintenance platforms in individual segments of the overhead contact line while simultaneously energising adjacent segments of the overhead contact line as needed in order to move vehicles.

Solution

Function

Four of the indoor tracks have identical equipment. In the vicinity of each individual segment of the overhead contact line, the roof maintenance platforms are fitted with separate stairs and a locked access door, as well as multiple emergency escape routes.

The fifth indoor track is fitted with two mobile roof maintenance platforms. The mobile roof maintenance platforms are also fitted with separate stairs and a locked access door, as well as emergency escape routes.

In comparable facilities built in the past, employees are protected by a key system. When the working range is in an earthed state, each employee who wants to enter the facility has to remove a key from the key system. This key is used to enter the working area and employees have to carry it on their person. It is only possible to de-earth the

overhead contact line section and energise it if all the keys are inserted into the corresponding locks of the locking system and are switched to the "on" position. This precludes accidental switching on. The keys therefore act as a form of "life insurance" for employees.

For the project in the Rummelsburg ICE maintenance floor, the client requested that an employee be able to enter the roof maintenance platform from any access door to the working area and also be able to exit the platform from any access door. If a key system were used, the employee would have to walk back to the key system from which they had initially removed the key. Given the length of the trains, this could involve walking up to 200 m, which also takes up significant amounts of time. For this reason, the key system was replaced by a transponder system.

Figure 2: Control panel with touch monitor (1) and transponder reader (2)

Control technology

The central control cabinet for a track is the centrepiece of the ADES. The central control cabinet contains a failsafe Siemens S7-1516F-3PN/DP control system (SIL 3 according to EN 61508) on which the standard control software and the safety control software are implemented. Failsafe input and output modules monitor and control safety-relevant peripheral components, such as the overhead contact line disconnectors, earthing switches and emergency-off buttons. Non-safety-relevant peripheral components, such as the El6 signals, are monitored and controlled by standard input and output modules. All the information comes together in the central control cabinet, where it is also processed.

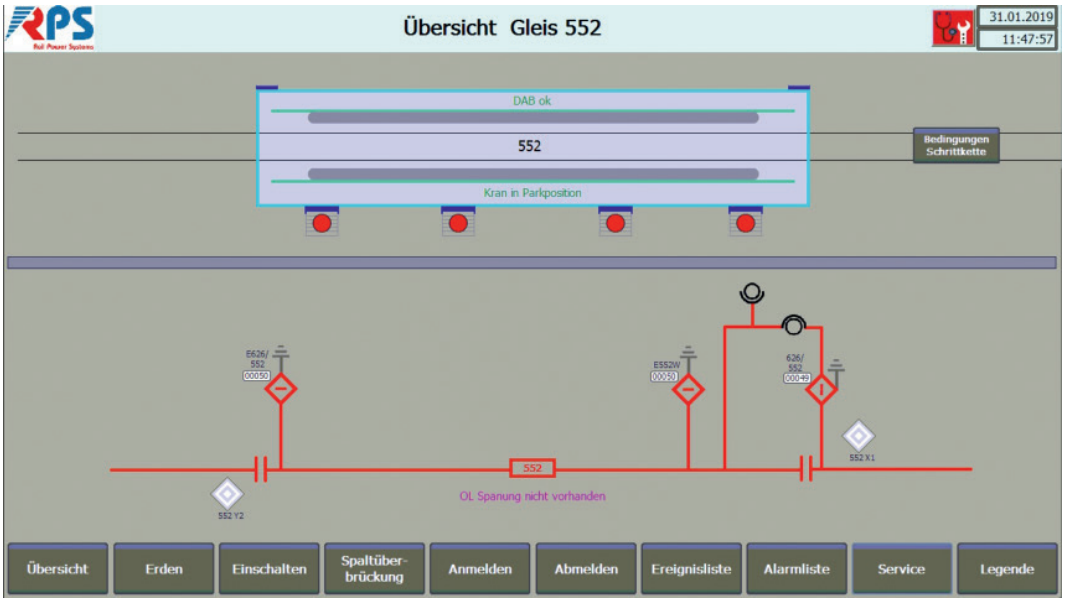
In addition to the auxiliary relay and connection terminals, the central control cabinet houses the following components:

- Isolating transformer for generating a network configuration of IT type to supply the entire system
- Uninterruptible power supply (UPS) for the system's maximum power requirement (all switch actuators can be operated simultaneously) and for an availability time of two hours
- Network Time Protocol server (NTP, determines the time) with GPS connection for time synchronisation of the control components
- DP/DP coupler (Profibus decentralised peripherals) for coupling to the operational management computer
- Router for communication with the central control room

A fibre optic cable ring with the PROFIsafe protocol connects the two control panels (Figure 2). These house the following control elements: touch monitor, buttons, signal lamps and an acoustic signalling device.

The system is operated from the two control panels using the touch monitor (Figure 3), buttons and signal lamps. The control panels are installed

Figure 3: Screen display



directly next to the access stairs to the roof maintenance platform. Each operator control action can be carried out on either of the two control panels. The system prevents rival operator control actions.

At the control panel, there is a transponder reader for logging in and out and for identifying employees who are authorised as an administrator or to perform earthing. A second transponder reader is installed on the access door for access control.

From the control panel, the emergency-off buttons, limit switches and access control lamps are connected to the AS-i bus in order to reduce installation work. This is a manufacturer-independent bus system in which actuators and sensors are connected to the control system by an unshielded two-wire cable. Data and power are transmitted simultaneously along this cable [3]. Acoustic signalling devices, rotating mirror lights and the unlocking system for the access doors are connected directly by cables.

Functional safety

For safety-oriented applications in the railway sector, the following standards must be taken into account: EN 50126 [4] (fundamentals), EN 50128 [5] (software) and EN 50129 [6] (hardware), all three of which are based on basic standard EN 61508. These standards describe the measures to be taken to ensure safety on the basis of specified requirements. Figure 4 and Table 2 show risk graphs and a risk assessment to demonstrate how SIL 2 is derived.

The Berlin-Rummelsburg ICE facility project involves a software-based safety solution, so EN 50128 applies. A corresponding project personnel structure was created in order to develop the software (Figure 5). The software development is documented in accordance with this standard. The software has been successfully appraised by an independent inspection body.

Components of the control technology

The TIA portal V14 SP1 (Totally Integrated Automation) was used to set the parameters of the facility control system. The portal's libraries support all the necessary functions. Components, protocols and methods from different areas are used:

- AS-i-Safe protocol (emergency-off buttons, limit switches and LED displays)
- Write/read heads for transponders (radio-frequency identification, RFID)
- Profinet/PROFIsafe (fibre optic ring circuit or single feeder to control panels, roof maintenance platforms and to the other tracks)
- Profibus (connecting the operational management computer)
- IEC-104 protocol (central control room connection)
- SIMATIC WinCC (operating system for control panel)
- FailSafe (CPU, input/output modules)

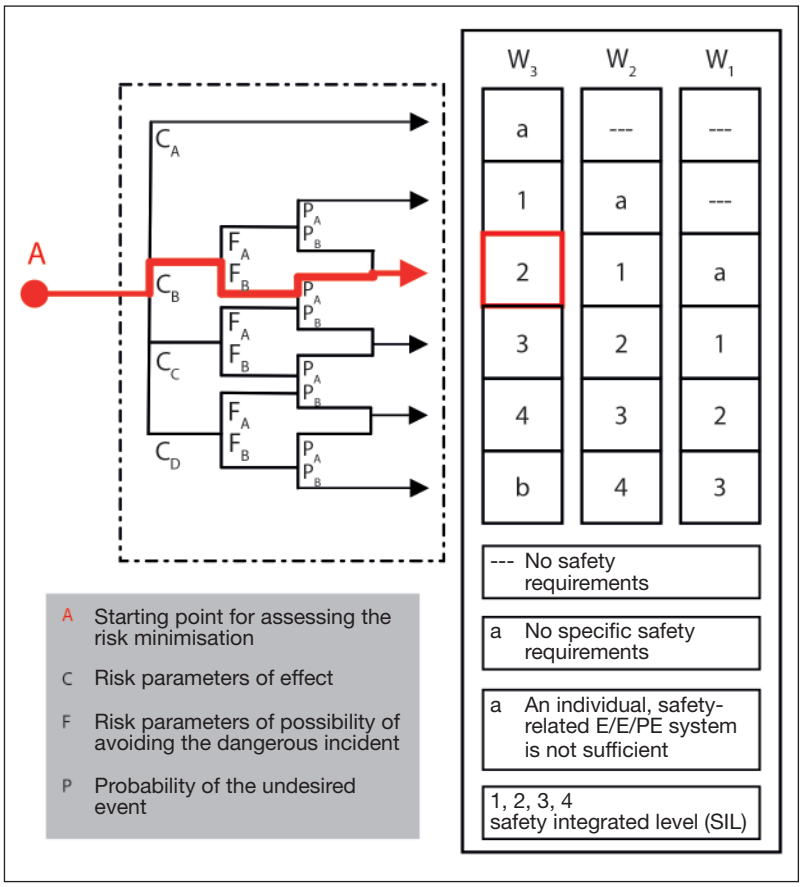


Figure 4: Risk graph and determination of SIL level

Table 2: Risk assessment according to EN 61508

Risk parameters	Assessment
C – risk parameters of effect	B – serious irreversible injury, death (contact with overhead contact line voltage)
F – risk parameters of frequency and duration of presence	B – frequent to continuous presence in dangerous area (daily work on the vehicle roof)
P – risk parameters of possibility of avoiding the dangerous incident	A – avoidance possible under certain conditions (some work can theoretically be carried out while maintaining a safe distance)
w – probability of the undesired event	3 – relatively high probability (daily operation)

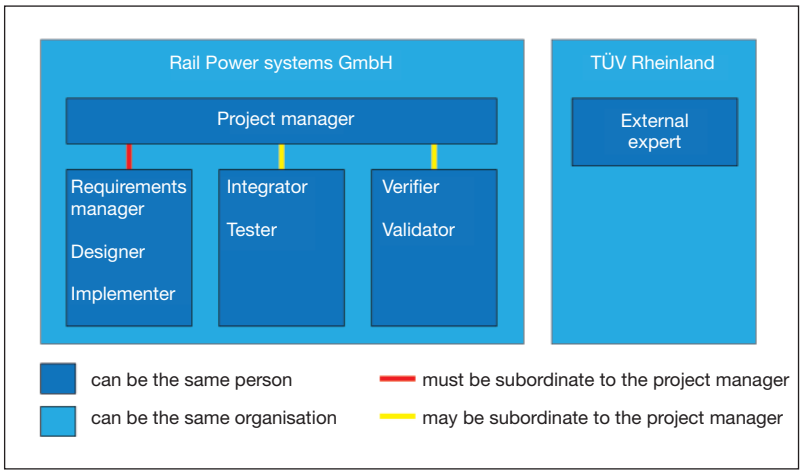
Functions

Earthing with gap bridging

Personnel are only permitted to enter and work on a roof maintenance platform when the overhead contact line system is earthed in the work area. Furthermore, for reasons of occupational health and safety, it is necessary to mechanically close the gap between the work platform and the vehicle roof by means of what is known as gap bridging. The purpose of this function is to ensure that the work platform can only be entered when the overhead contact line is earthed and the gap bridging is established (Figure 6). This function is operated from any control panel on the track.

To carry out the "earthing" switching operation, employees have to identify themselves as switching-authorised at a control panel using their transponder. External transponders are not accepted by the system. The employee selects a

Figure 5: Personnel structure for SIL2 applications acc. to EN 50128:2011



work area on the touch monitor and starts the earthing by performing a two-handed operation.

The following sequence starts for the selected work area:

- Visual and acoustic warning
- El6 signals light up
- Disconnectors open
- Check that overhead contact line section is dead
- If it is dead: earthing switches close (connection to return line)
- Gap bridging device extends with monitoring of end position
- Access doors released

The status display on the overview image at the control panels is continuously updated during the process flow. In addition, the signal lamps in the upper part of the control panels indicate the status of the overhead contact line segments.

Identifying persons

The roof maintenance platform can only be accessed after logging in with an employee transponder. To do this, employees have to log in to a selected work area using the “Login” screen at a control panel. This involves reading in the transponder via the RFID write-read head at the

Figure 6: Roof maintenance platform from above

control panel. The employee selects the requested work area. When the employee logs in, the transponder UID (user identifier) is entered into a table for the line segments in question. If the login is successful, this is indicated on the screen above the relevant segments.

The transponder UID is also added to the table of persons logged in. The screen closes automatically. While the screen is activated, operation is blocked on the other control panels for the track. A transponder can also be assigned to multiple work areas.

When an employee logs in, the work area is locked against reactivation by others. Logging in is therefore equivalent to removing a mechanical key in the conventional system. It is only possible to energise the system once all the transponder UIDs for a work area have been deleted again.

Access

The roof maintenance platform can only be accessed via the staircases. These are secured by the access doors and the corresponding door locking mechanism (Figure 7).

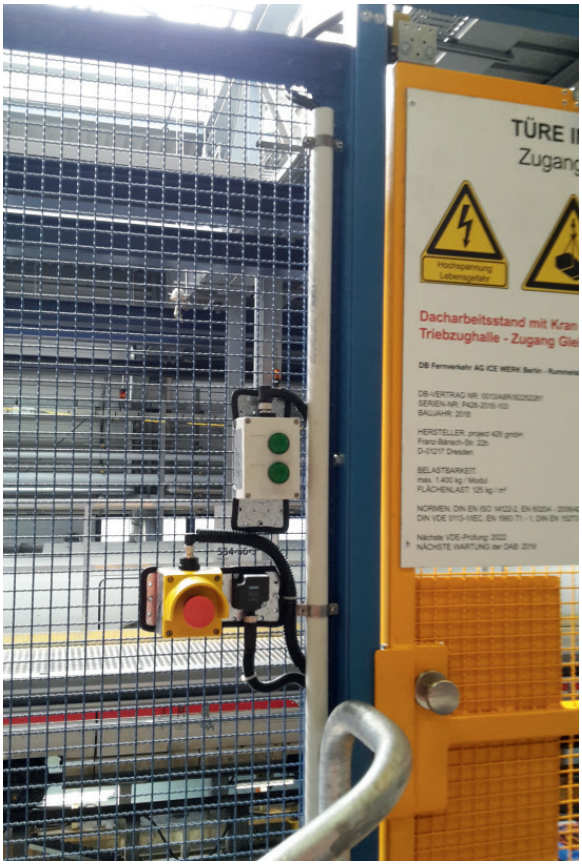


Figure 7: Controls on the access to the roof maintenance platform

To enter the roof maintenance platform, employees must hold the transponder that they used to log in at the control panel against the RFID write-read head on the access door. The door is unlocked for a short time so that it can be opened. This is indicated by a green lamp on the door.

The access door can only be unlocked if the following conditions are met:

- Work area is earthed and gap bridging extended
- The gap bridging must have come up against an obstacle/vehicle in the area of the access door (protection against falling)
- Employee is logged in to the work area in question
- No malfunction in the system

Employees can exit the roof maintenance platform and enter it again provided that they do not log out at the control panel. To re-enter the roof maintenance platform, employees must first identify themselves at the access door with their transponder.

No transponder operation is needed to exit the platform. The access doors are opened manually from the inside. The ADES control system does not evaluate employee exits from the roof maintenance platform. An employee can leave and re-enter the maintenance platform from any work area access point.

Logging out

Before the overhead contact line segment for a work area can be switched back on again, the assignment of all employee transponders to the relevant work area has to be cancelled. This is done at any control panel for the track by reading in the employee transponder and logging out of the work area. Once this is done, the work area can no longer be entered using this employee transponder without logging back in first.

To log out, employees have to access the corresponding screen on the touch monitor. Employees log out in two steps. In the first step, employees read in their transponder. In the second step, employees enter their personal identification number (PIN) on a keyboard. If the PIN entered matches the transponder, the logout is accepted. This two-stage logout procedure increases safety. The logout procedure is equivalent to inserting a mechanical safety key in the conventional system.

De-earthing and energising

The overhead contact line of a work area can be energised if the following conditions are met:

- All employees have logged out of this work area
- All cranes in the work area are in the parked position
- The access doors for the work area are closed and locked
- The front guard rail and carriage crossover mats are in the home position
- The emergency exit ladders are in the home position
- There is no emergency shutdown present
- There is no malfunction message present

The screen for switching on only opens after the switching authorisation has been checked via the transponder, preventing unauthorised persons from triggering operation. The work area to be switched on is selected at the control panel.

This switching-on process is initiated by pressing both "two-handed operation" buttons. The following sequence starts:

- Visual and acoustic warning
- The gap bridging retracts
- The earthing switches open
- The supply switches close
- The El6 signals go out
- The status display on the screen at the control panels is continuously updated during the process flow. The steps are monitored and only executed if the respective previous step was completed successfully.

If the process is interrupted by an emergency shutdown or a malfunction, it cannot be restarted. Once the emergency shutdown state is eliminated or the malfunction is repaired, the system must first be earthed to bring it to a safe and defined basic state. The switch-on process can only be carried out from an earthed state.

Earthing without gap bridging

For some tasks, the overhead contact line system for a track needs to be completely earthed without there being any need to access the roof maintenance platform, such as for maintenance work on the hall gates, for example. In this case, all the segments should be earthed without the gap bridging device being extended.

An additional software function was implemented in the ADES for this purpose: this makes it possible to earth a track in its entirety (all segments).

Earthing without gap bridging can only be carried out under specific conditions:

- There must not be any employees on the roof maintenance platform (all transponder UIDs logged out)
- The overhead contact line of all segments is switched on
- All access doors and emergency exits are closed
- There is no emergency shutdown present
- There is no malfunction present

If all the above-mentioned conditions are met, earthing without gap bridging can be started by means of a two-handed operation.

Emergency shutdown of the overhead contact line

An emergency shutdown function is implemented in the ADES as a safety function; when it is requested, all overhead contact line sections are immediately switched off and earthed.

When the latching "emergency shutdown" mushroom button is pressed, the ADES:

- Switches on corresponding warning lamps and an acoustic signal
- Switches off all feed switches
- Next, all earthing switches are switched on, to prevent neutral overhead contact line sections.

This completes the emergency shutdown function. Rescue measures can now be carried out.

The acoustic signal for an emergency triggering can be switched off at any control panel or at the central control cabinet by pressing the "Acknowledge malfunction" button. The visual display remains. Table 3 shows the possible causes of an emergency shutdown.

Once rescue measures have been carried out, an emergency shutdown present at the ADES central control cabinet has to be acknowledged with the "Acknowledge emergency shutdown" key-operated acknowledgement button. After this, the ADES can be operated normally.

Table 3: Causes leading to an emergency shutdown

Cause	All tracks	Only initiating track
Activation of an emergency earthing button	X	
Unauthorised opening of a roof maintenance platform access door		X
Use of a roof maintenance platform emergency exit stair or ladder		X
Unauthorised crane position		X
UPS deep discharge		X

Outlook

The last track was put into operation in August 2019 and has been running in normal operation ever since.

In 2020/21, the vehicle hall will be extended to a total length of around 420 m. A disconnection point is being built in the middle of the hall. This will create two segments of roughly the same size that can be switched individually or in groups. In the process, technical machinery such as the roof maintenance platforms, cranes, busbars etc. will be extended into the new building. The automatic disconnection and earthing system will be expanded to include the new functions.

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