Fenix
RAIL SYSTEMS

400 FenLock Control System

FS-DES-STD-03
Version 5.0

1. Abbreviations & Acronyms

Term	Definition
CCTV	Closed Circuit Television
CCU	Central Control Unit
FCS	Facility Control System
Disbox	Disconnection Box
DPPS	Depot Personnel Protection System
EMC	Electromagnetic Compatibility
EU	European Union
FTN	Fixed Telecommunications Network
HD	High Definition
HMI	Human-Machine Interface
I/P	Input
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LOPS	Locally Operated Point System
NR	Network Rail
O/P	Output
REB	Relocatable Equipment Building
RSSB	Rail Safety and Standards Board
RSP	Route Setting Panel
SIL	Safety Integrity Level
SPT	Signal Post Telephone
TD	Train Describer
TOC	Train Operating Company
UPS	Uninterruptible Power Supply
Vac	Volts, alternating current
Vdc	Volts, direct current

2. Introduction

2.1 Executive Summary

This document provides the system description for the FenLock 400 Facility Control System (FCS) for use in depots, intermodal facilities, yards and other non-mainline applications. The 400 DCS is the most advanced system of the series, providing a full signalling solution.

Description	
100	Point Machines operated by individual plungers located by each set of points, combined with a Points Position Indicator (optional).
200	Point Machines operated from a Point Setting Panel, one switch per point. Position of points indicated on panel. Points Position Indicators provided with optional plunger to operate points locally.
300	Point Machines operated centrally from a Route Setting Panel (RSP) or VDU. Points in a route operated by a single button. Optional PPIs, axle counters for train detec- tion plus limited interlocking e.g. for an interface to a mainline system, provision of a slot or Shunters Acceptance.
400	Point Machines, standard NR GPL signals controlled from a Route Setting VDU. Axle counter train detection provided to give a full but simplified interlocking, e.g. signals won't clear unless points in correct position and axle counter sections clear. Able to relay interface with NR signalling functions, other Depot Protection Systems, CCTV sys- tems etc. Suitable for remote operation. Additional features.
500	Features all the above including Point Machines, standard NR GPL signals controlled from a Route Setting VDU. Axle counter train detection provided to give a full interlocking plus additional functionality and integration, Train identity remote control operation.

Fenix Rail Systems recommend the FenLock 400 FCS for its centralised depot control features, flexibility, low operating costs, legacy support and standardised interface to Network Rail (NR) mainline interlockings and Depot Personnel Protection Systems (DPPS).

Fenix Rail Systems are a provider of FenLock Systems in the UK, working in partnership with our strategic supply chain to deliver a range of services and solutions for UK depots. Some existing UK installations are:

- Northampton Gateway Intermodal FenLock 400 system (2024)
- Daventry International Rail Freight Terminal 400 system (2023)
- Nexus Gosforth Depot Newcastle New Build facility (2023/24)
- Bombardier Central Rivers extension. Modification to an existing 400 installation (2001) to provide an additional stabling road (2018)
- Chilterns Banbury Depot, Banbury. 400 installation with 7 point ends, fully interlocked with signals and interfaced to the mainline (2016-17)
- Alstom Golders Green Depot, London. A London Underground application (2006)
- Chilterns Wembley Depot. 400 installation incorporating 8 point ends (2004)
- Alstom Morden Depot, London. 400 installation .A London Underground application with 32 point ends (2004)
- ABP Immingham Depot. 400 installation incorporating 10 points and 1 Route Setting Panel (2002)
- Siemens Southampton Depot. 400 installation incorporating 10 points indicators and approximately 25 axle counters (2002)
- Bombardier Central Rivers Depot, near Derby. 400 installation incorporating 29 point ends, point position indicators throughout and axle counters (2001)

2.2 Overview of Benefits

The main benefits of the 400 system are:

- Known to be a reliable and cost-effective solution;
- Additional functions including Call-on and Car Counting;
- Minimal maintenance - low life cycle cost;
- Over 1,000 systems worldwide since 1984;
- Developed & compliant with EN standards; including safety integrity levels (SIL);
- Systems have been installed in all types of electric traction areas and are fully compliant with EN50121-4;
- Lifetime 2nd line support - UK installations since 1989 are still fully supported for spares, technical support & O&M training;
- Operates in harsh environments including coal yards, harsh winters (e.g. in Finland & Poland);
- Full uninterruptable power supply (UPS) provided to mitigate power failures; current location of vehicles will be maintained;
- Full vehicle detection and interlocking provided; prevents conflicting train movements and derailments;
- No/reduced need for hand shunters - eliminates/reduces risk of staff slips, trips, falls, being struck by a train etc. as well as providing labour cost savings;
- Depot can be remotely controlled from any location;
- Trailable, low-maintenance point machines;
- Reduced capital cost vs mainline systems;
- All system actions/ events are recorded and saved for future access (remotely if required);

3. Operational overview

3.1 General Operational Overview

The FenLock 400 system is presented on the Visual Display Unit (VDU) in front of the user. Any equipment controllable by the user can be clicked with the mouse using the left-click for standard operation and a right-click for failure/administrator roles.

As an additional feature, the software can be configured to show a car count, which is achieved by taking the axle count and dividing by the number of axles per car/carriage/coach (typically 4). This is visible in Figure 1, circled in blue, which becomes of benefit when permissive working is specified as it allows the operator to see the remaining stabling capacity.

Each interlocking request also features a yes/no option to complete the operation. This is to prevent accidental requests. Fault messages and degraded mode operations provide an additional pop-up image and window and each must be acknowledged before the system executes a new request.

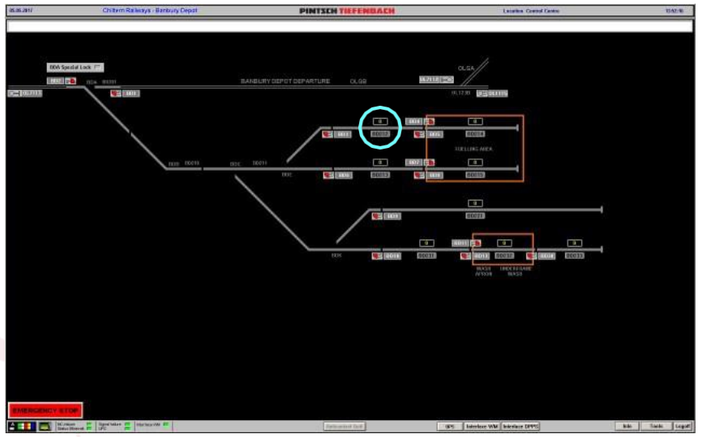


Figure 1 - VDU with route set, track occupation and car count (blue circle)

3.2 Example of Operation

The most commonly used function on a FenLock 400 system is setting a route which is performed by 5 mouse clicks:

START → **FINISH**

1. Click on the signal at the start of the desired route,
2. Select "START" from the drop-down list that appears,
3. Click on the signal at the end of the desired route,
4. Select "DEST" from the drop-down list that appears,
5. Click YES

A message appears "Set route A to B?" with buttons YES and NO. The YES/NO are blanked out for 3 seconds before becoming available to mitigate erroneous setting.

If the route conditions are satisfactory, the route sets and a message "Route A to B set" appears and the VDU reflects lineside equipment states.

If the route conditions are not satisfactory (e.g. points locked in the incorrect lie), the route does not set and a message "Route A to B setting cancelled – Points C locked reverse".

Other equipment can be indicated and controlled by status indicators which are pop up boxes showing green for on and red for off, examples including:

- Mainline/other signalling system interface relay sent/ received status;
- DPPS road protection or electrification isolation status;
- Points heating controls and status;
- Level crossing barrier or warning sequence status.
- SPAD Alert and recording
- Locked Gate/Doors
- Simulator (Optional)
- Emergency Replacement Indications

3.3 Background Operations

The system automatically records each action taken on the system into an activity log. Each log entry includes the date, time, location and operator. Some items may include (non-exhaustive):

- Failure of wayside equipment;
- The successful setting a route or interlocking request;
- The unsuccessful setting of a route or interlocking request; and
- A change in interface relay or other equipment state.

The log can be downloaded from the interlocking or viewed on the VDU and is generally an aid to fault finding exercises.

3.4 Multiple VDUs

There is flexibility in having multiple operator's desks (i.e. two separate VDUs in separate locations). The same connection applies and is via a secure and reliable network (ethernet) cable. The multiple VDU setup is configured in such a way that it is possible for only one of the terminals to be designated the master at any one time. A secure function is built into the user interface to enable the hand-over of control and uses a multiple action command to permit the currently active master to designate another terminal as the new master.

4. System overview

1. System Characteristics

1. Overview

This section describes, in brief, the purpose of each section of the FenLock 400 system

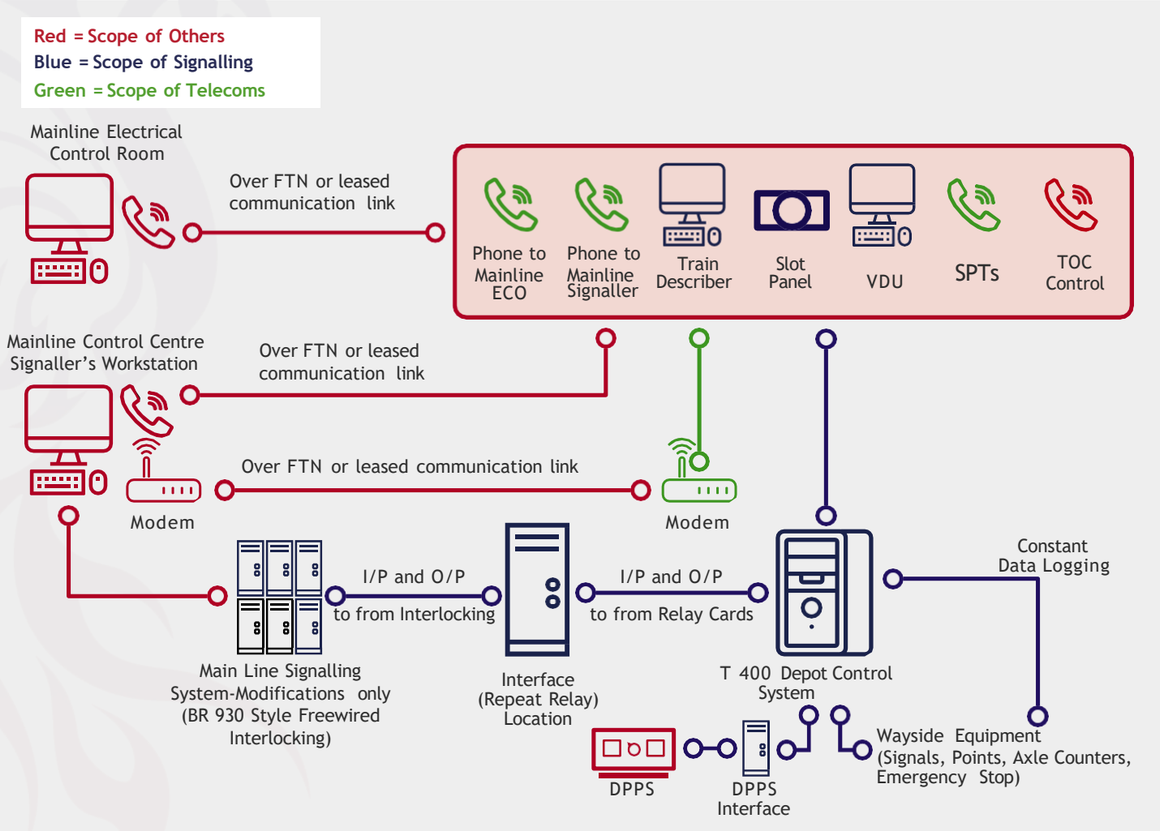


Figure 2 - System block diagram of a typical 400 depot installation

The main function of the Depot Control System is to provide a signalling interlocking. The interlocking is designed to prevent conflicting train movements and to provide a safe state in the event of a failure. The VDU is the human-machine interface (HMI) from which the operator can make interlocking requests. This request (route setting etc.) will go through the interlocking, which analyses the status of the wayside equipment (track sections, point machines, other set routes etc.) and approves/rejects the request. If the request is approved, the route state and wayside equipment state changes to allow one train movement.

The philosophy of a centralised control is achieved by providing all controls available to the operator within one location. Using Figure 2 as a typical installation, the "Depot Signaller's Control Desk" is the location of all signalling and communications devices available to the operator. This includes all signalling controls, CCTV controls and screens, telephones to SPTs/TOCs/mainline entities (as required) and any degraded operation controls (such as point keys and handles).

The mainline functional interface is becoming a more prevalent feature of depot designs following the introduction of the following documents:

- Network Rail standard NR/L2/SIG/30009/C320 - Interface between Running Lines and Sidings or Depots, compliance date 1st December 2018
- RSSB Guidance Note GIGN7621 - Guidance Note for the Development and Design Considerations of Passenger Rolling Stock Depots, released in September 2018

It has now been stated that train movements are to be less reliant on voice communications and these should be avoided. Where a mainline interface is proposed a safe method of working shall be established. This can be achieved by creating specific routes to/from the mainline, controlling these routes using the mainline control system and a slotting arrangement under control of the depot operator.

The system also provides provision for a train describer for interposed headcodes to be transmitted to the mainline train describer system.

The DPPS interface allows safe movements of trains into and out of areas where there is a risk of injury from train-human interaction due to increased human activity in a depot area or collision with track mounted equipment, such as in a maintenance shed or wheel lathe. A slotting arrangement, controlled by the DPPS operator, can allow or block movements into or out of the area dependent on the conditions within the DPPS area. This interface can be made to work automatically in the event that no staff are present.

The system is highly scalable. It is capable of providing control and indication for depots of significant complexity. This is due to the modular interlocking and wayside architecture enabling the overall system to be separated into multiple substations. Logical division of the interlocking is recommended for installations with over 60 items of signalling equipment. Equipment counts higher than this are possible but, depending upon the depot layout, this could be to the detriment of system processing speed.

The largest installation is located at Gdansk depot, Poland. The depot consists of 4 substations which control 100 point machines, 180 axle counter heads and 150 signals. Each of these substations communicates (bi-directionally) with the main interlocking processor.

All systems are compatible with relevant EU EMC standards to all traction types. Outdoor equipment has a temperature operating window of at least -40°C to +70°C. and CENELEC Safety Integrity Level Up to SIL 4
The axle counters can be safely traversed at speeds of up to 60kph (~37mph) although a typical depot speed limit is usually less than 15mph.

4.1.2 Computer Based Interlocking

This is the “heart and brain” of the 400 system. The Central Control Unit (CCU) is certified Up to SIL 4 and is battery buffered by an uninterruptable power supply (UPS) to prevent power loss. In the event of a total power loss/UPS failure the internal memory is not lost. The CCU collects and distributes data to all wayside equipment and feeds the information to the Central Processing Unit (CPU). The CPU contains the interlocking data, which is bespoke to each installation. The interlocking data can be written to adapt to and abide by any country’s signalling principles with no limitations which may include permissive working or long route setting (non-exhaustive).

The operator’s VDU is connected to the CPU, which takes the operator’s inputs on the VDU and checks against the CCU interlocking data before granting or blocking the action requested by the operator.

All equipment is fed from and reports to an “interface card” which is mounted within the location cabinet/REB (see section 4.2.2). Each card communicates with other cards and the CCU.

Figure 3 – SIL 2 System show here

The CCU is largely maintenance free, with no scheduled upgrades unless required by depot expansion. The system performs self-diagnostic routines which flags untoward occurrences and failures. Upgrades to the software can be implemented by installing a new CPU, which allows for easy installation of new roads, signals and points etc.

The system boasts a modular design philosophy which is created from high grade industrial components, thus increasing the availability of spare parts and reducing maintenance costs. The system is constantly performing self-checks on the circuits and reporting faults, which means that malfunctioning units can be swapped very quickly and easily. The metal plates on the front (see figure 1) can be taken off, exposing the card beneath. This card has a part number and pin-code, meaning only a card of that type can replace the original.

2. System Architecture

1. Equipment Housing

1. Overview

The FenLock 400 system is installed in location cabinets, preferably in internal housing such as a control room or REB for ease of maintenance but can also be externally located. Unlike typical NR location cabinets, these are mounted on a swinging frame and therefore provides access from one side. The frame is made up of two columns of eight 19" racks (although typically only a maximum of 7 are used to allow cable installation and access in the base of the location), on which the cards to control and process wayside information is mounted, as well as the CCU and CPU.

288
Digital Critical inputs per rack;

86
Digital Critical outputs per rack;

CENELEC Safety Integrity Level Up to SIL 4

An additional external cabinet can be provided for terminating and distributing the incoming power supply. This cabinet is smaller than the cabinets depicted in Figures 3 and 4. The UPS can also be located for electrical convenience within this cabinet. The UPS is typically specified for axle counting back-up purposes and not for signal and points power, but it can be specified for any purpose, voltage or time period to suit specific project requirements.

Figure 4 - Design drawing of two 19" racks, controlling 4 point machines
Note systems show here is a typical SIL 2 system.

4.2.1.2 External

The external cabinets are mounted on a stainless-steel base, which is directly buried into the ground. The base allows for cable entry and exit and features removable panels to allow access for maintenance and to provide protection to the cables entering the base of the cabinet. Cables are attached directly to the bottom of the cabinet by suitably rated cable glands and armour can be earthed.

Figure 5 - External location cabinet (frame closed)

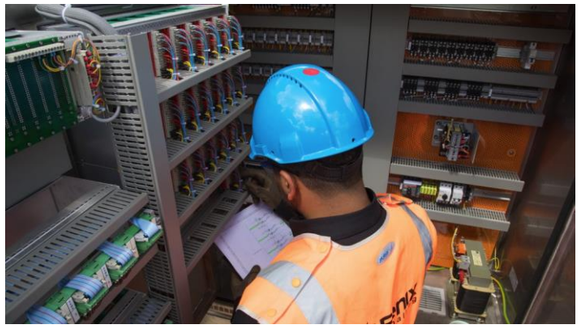


Figure 6 - External location cabinet (frame open)

4.2.1.3 Internal

The racks and frames are also compatible with indoor application, where a glass fronted cabinet can be mounted to the floor or wall within a designated building, or within a relocatable equipment building (REB). This is beneficial as a centralised system offers easier maintenance (access to all of the system in one location, protected from weather, reduced cost of exterior cabinets, concrete bases etc.)

Figure 7 - Wall mounted internal location cabinet (undergoing factory testing)

4.2.2 Point Machine

The FenLock 400 system uses low-maintenance trailable point machines which are robust and mounted in the four foot. The machine can be installed in approximately 80 minutes and tested and commissioned in under two hours, saving considerable time and cost on site compared to rival machines. It is mounted on two cross members which clamp to the outside foot of the rail and the overall height of the machine is below the standard BS113 rail running height. A six-foot mounted version is also available, depending on client requirements/site layout restrictions.

Figure 8 - Point machine installation

The detection and power are supplied by a single cable, with a minimum of 5 cores. The power supply is currently a three-phase 400Vac supply, although a 120Vdc variant is in development. The maximum cable feed length is 1000m when using a 1.4mm2 cable, or 500m when using a 0.9mm2 cable.

The points machine features an internal mechanism allowing the machine to be safely used in a trailing direction without damaging the components. The machine can be installed with a plate which allows the integration of a standard six-foot mounted back drive. In the event of a power failure, the machine can be operated manually by inserting a key to engage manual operation and then turning a crank handle. Various throw lengths and times can be specified and supplied.

The machine requires minimal maintenance at an interval of every 6 months, which is limited to the exterior of the machine. This is normally to account for vibration and wear in the turnout. It includes adjustment of the detection rods and maintenance of the screw thread to prevent rusting, in addition to re-torquing the bolts.

When an over-running and/or a trailing move is detected, if safe and in combination with the axle counter system, the points automatically throw the points to the non-trailing position to prevent damage to the infrastructure/train.

The machine is driven by an electric motor which is geared down to drive the switch blades by two rods. The rods feature a spring mechanism to prevent breaking when the machine is trailed. The detection is achieved by four micro switches attached to two detection rods.

4.2.3 Points Position Indicators

These are not provided for FenLock 400 Systems

4. VDU/Control Panel

1. VDU

The purpose of the VDU is to be the HMI to the depot controller enabling safe control of train movements with indication of track and wayside system status. The information displayed and colours on the VDU can be customised to the client's requirements, although typically the colours are to NR standards.

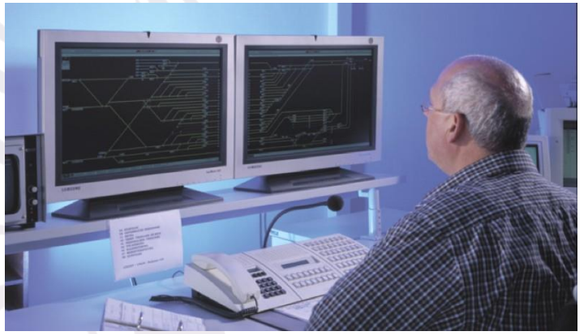


Figure 9 - VDU at Cologne Depot, Germany

Figure 10 - VDU at Banbury Depot, UK (NR slot panel to left)

Depending on the size of the depot, one or multiple LCD (being SD or HD) monitors are provided along with a compact desktop computer, mouse and keyboard. All other signalling and telecommunications equipment (e.g. slot panel, train describer, emergency alarms and telephones) should be mounted locally to the VDU, in order to achieve centralised control for all movements.

4.2.4.2 Control Panel

Because of the complexity of a FenLock 400 and the simplicity of operating and updating a VDU system, control panels are not provided for FenLock 400 systems

4.2.5 Signals

The FenLock 400 DCS typically uses Network Rail approved LED Position Light shunt signals, showing red/red for danger, clearing to white/white at 45° for proceed, although the system can interface to most LED indicators, approved or bespoke.

These are typically mounted near ground level on a concrete plinth. Alternatively, the signals can be mounted on posts; this enables a train to stand closer to the signal, thereby increasing stabling room and capacity.

The signals are directly fed from the interlocking, as the cable is attached to a signal card within the location cabinet.

The signals are effectively maintenance free and only require inspection and cosmetic maintenance if necessary. Typically, signals are fed at 110Vac. However, the system can accommodate any signal type or indicator with a reasonable voltage requirement. The maximum feed length for a 2.5mm2 cable is over 10km.

Figure 11 - Post mounted LED position light shunt signal

4.2.6 Train Detection – Axle Counters

The axle counter for the FenLock 400 is Certifiable upto SIL-4 system which informs the operator of track occupancy and provides vital interlocking functions. A SIL-2 version is also available for when SIL-4 is not required however e the cost of a SIL 4 is now cost effective and is comparable to SIL2 systems.

Figure 12 - Axle counter mounted on rail, and disbox (background)

The axle counter head is a dual proximity switch, designed and manufactured to detect the flange of the wheels passing over the switches. With each detected wheel, the axle counter counting card sends a package of data to the switching amplifier, which is within the location cabinet.

The cable connecting the axle counter to the disconnection box is a fixed tail cable, of varying lengths depending on specification. The cable from the location case to the disconnection box is usually a 2-pair telecoms-style cable, however if two axle counter heads are mounted close to each other, it is possible for the two heads to share a 4-pair (up to 5-pair) cable, as the axle counter head disconnection box allows this.

The axle counter heads require little maintenance; a biannual visual inspection for damage and clearance to the height below the railhead, an annual test and, if necessary, adjustment of the detection mechanism.

The axle counters can be located at a maximum of 2200m when using a 1.4mm2 cable under harsh EMC environments, or up to 8,600m when using a 1.4mm2 when using an earthed shielded cable.

4.2.7 Movement Authority

FenLock 400 is provided with Network Rail style ground position light signals. These provide movement authority for drivers in the same way that they do on the mainline. They also mark the end of the authority. Communication with drivers and the risk of confusion is thus much reduced with FenLock 400 systems.

4.2.8 Cable Routing

It is recommended to run two separate or segregated troughing routes, one for the point machine cables and signal cables, the other for axle counter and other data cables. This removes the chance of interference between the cables. If this cannot be achieved it is satisfactory if a 50mm air gap is maintained between the two cable sets.

Typically, copper cable cores are used. However, for cables used for data purposes (from the interlocking to the VDU, axle counters etc.) a fibre-optic cable can be specified.

In areas with harsh EMC environments, earthed cable sheathing may be required for long cable runs to maintain compliance and to mitigate voltage induction.

4.2.9 Power Supply

The 400 requires a 3-phase 400Vac supply to a separate power cabinet or enclosure where it is transformed down and/or distributed as required. The interlocking components predominantly run off 12V and 24V, with the exception of the signals (110Vac) and point machines (400Vac).

A 30 minute back up power supply is generally provided for the axle counter logic computer, to allow for axle count and train position memory, allowing a quicker recovery time/reducing downtime.

4.2.10 Points Heating

A centralised points heating system can be integrated into the depot signalling system to show faults, warnings and system operation on the user's VDU. The system can also be turned on and off using the buttons on the VDU.

3. System Interfaces

1. Interfaces to Other Equipment

Relay cards are available to install within the card racks, allowing almost any technology to be interfaced to the interlocking. This may include:

- DPPS interfaces;
- Mainline interfaces;
- Manual gate controls;
- Level crossing barrier controls;
- Points heating controls.

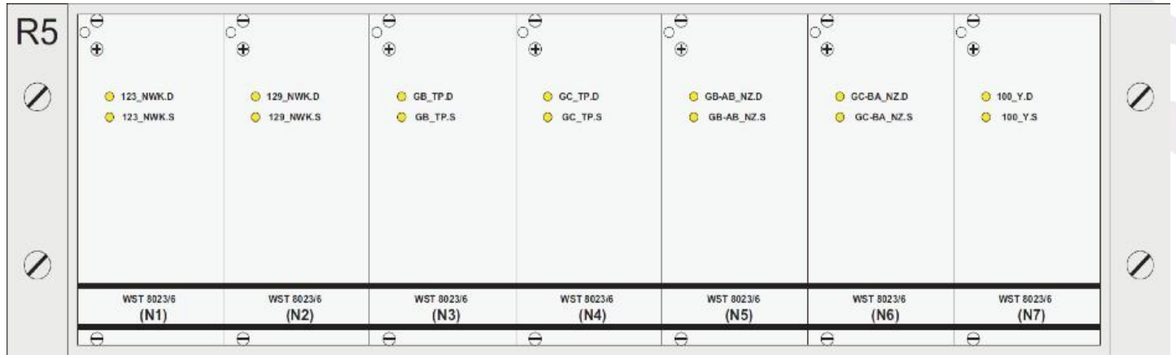


Figure 13 – SIL 2 Relay card rack for interface functions

Each relay card has two sets of two antivalent contacts (one set normally open, one set normally closed) meaning that double cutting contacts into the circuits can be achieved. For outgoing circuits to Network Rail location cases, a BR-spec transformer is used to provide earth-free power.

Should a different type of point operating equipment to section 4.2.6 be specified, the relay cards can be used to gather detection information from the points operating equipment.

4.3.2 Mainline Interlocking

The FenLock 400 system can be interfaced to any type of interlocking (such as but not exhaustive: electro-mechanical, relay, SSI or CBI) by implementing an interface with BR930-style relays. The relays can be housed in a separate interface location case amongst the mainline suite, within the depot suite or within the depot signalling equipment room. This arrangement creates a volts-free contact bridge, meaning the systems can operate independently from each other and maintain immunity. An interface functional specification shall be written beforehand to ensure all relevant functions are sent and received from each interlocking. Typically, a slot arrangement is required to ensure a systematic and operator handshake is achieved.

Emergency alarm systems can be integrated into the FenLock 400 VDU and interface. The system also features an emergency all signals on control button on the VDU.

Typically, a train describer does not interface with the FenLock 400 system as it is more efficient for the fringe signal box to perform this action, or the user to interpose headcodes into a separate TD monitor.

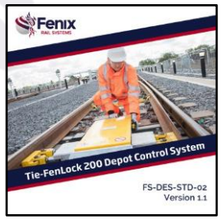
4.3.3 Depot Personnel Protection System (DPPS)

Typically, a slot or other equivalent acknowledgement is required from the DPPS designated person prior to a train movement. This slot is sent to the FenLock 400 system and integrated in the controls of the appropriate signal. The DPPS shall send a movement authority slot when it is safe for a train to move into a DPPS area, allowing the route setting and aspect clearance. If it is not given, the route cannot be set.

5. Further information and reading

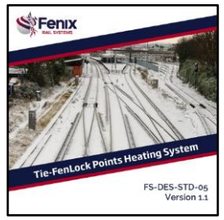
The 400 is the most advanced of the four DCS options and therefore may not be suitable for all depot applications. Further information can be found for the 100, 200 and 300 series in the following documents:

FS-DES-STD-001 - 100 Depot Control System – System Overview



FS-DES-STD-002 - 200 Depot Control System – System Overview

FS-DES-STD-003 - 300 Depot Control System – System Overview



FS-DES-STD-005 - Points Heating System – System Overview

FS-DES-STD-006 - Points Monitoring System – System Overview

Fenix Rail Systems provide signalling system consultancy and turnkey delivery (design, procurement, installation, testing, commissioning, handover and O&M) in the UK and worldwide for both greenfield projects and brownfield projects requiring complicated stageworks. Project delivery in the UK is aligned with Network Rail GRIP stages 2-8.

Our offices are open from 08.30 to 17.30 each day. Key management can be contacted via the office landline 03300 580180 and mobile numbers are provided for convenience outside office hours. Your main contact with Fenix Rail Systems are as follows:

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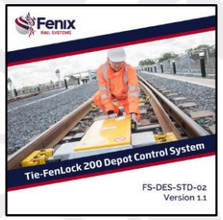
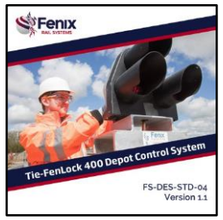
5. Further information and reading

The FenLock 400 is the second most advanced of the five FenLock Systems FCS options and therefore may not be suitable for all depot applications. Further information can be found for the 100, 200 and 300 series in the following documents:

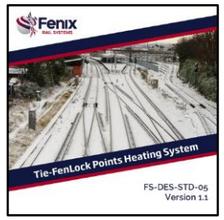


FS-DES-STD-002 - 200 Depot Control System – System Overview

FS-DES-STD-003 - 300 Depot Control System – System Overview



FS-DES-STD-004 - 400 Depot Control System – System Overview



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FS-DES-STD-006 - Points Monitoring System – System Overview

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