



(Minor changes to the previous edition are indicated by ◆ placed before the relevant paragraphs)

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1. Scope

This Specification is written to comply with Engineering Standard 1-202 in defining the requirements for the overhaul of all variants of the Point and Lock Detector Box which are used extensively in the signalling system on the London Underground.

The specification hierarchy which supports these requirements is detailed in Attachment 4 to the Specification

2. References

The text of this document cites other documents that provide information or guidance. These are listed in Attachment 1.

References to British Standards or standards in other standards systems shall be taken to include the words 'or equivalent'.

3. Abbreviations

The following abbreviations are used in this document (if from a published source this is indicated):

CPS	Critical Parameter or Setting
DCN	Design Change Notice
LU	London Underground
OEM	Original Equipment Manufacturer
P&LD	Point and Lock Detector
WSL	Westinghouse Signals Limited



4. Definitions

The following terms are used in this document (if from a published source this is indicated):

The Client – The Client is the Infracore representative responsible for administering the contract under which the overhaul work is being performed.

The Contractor – The Contractor is the organisation responsible for the delivery of overhauled equipment.

Normal – Normal refers to one of the two positions which a point layout may take in which a train may safely be authorized to run over the layout. It is usually the case, although not always, that the straight route through the layout is called the Normal one. The other route through the layout is called the Reverse route.

Reverse – Reverse refers to one of the two positions which a point layout may take in which a train may safely be authorized to run over the layout. It is usually the case, although not always, that the divergent route through the layout is called the Reverse one. The other route through the layout is called the Normal route.

5. Introduction

This specification has been written to detail the overhaul requirements of the 4-way and 6-way Point and Lock Detector Boxes (P&LD Box) which are used in the signalling system on the London Underground.

P&LD Boxes are classified as items of vital signalling equipment which means that they are used to perform a safety critical function directly affecting the safe movement of trains. It has been designed to be an ultra reliable piece of equipment whose mechanical integrity will be relied on throughout its extended working life. It is a mandatory requirement that a P&LD Box that has been overhauled shall have a functional performance, a safety integrity, a reliability, an expected service life in its installed condition and a shelf life equivalent to that of a new item.

Any failure condition which causes a set of points to be detected in other than their true position is classed as a 'wrong-side' failure. Wrong-side failures are investigated exhaustively to establish the cause of the failure. Investigations into wrong-side failures will examine materials, processes and the history of overhaul operations to establish the exact cause of the event and to ensure that no other items are likely to suffer a similar failure. An occurrence of a wrong-side failure, or a misoperation showing a tendency towards a wrong-side failure, even if no accident or damage is caused, can be extremely costly to investigate and could result in the need to change many units in service.

Items supplied for overhaul will be complete units which may be in working order or may have failed in service. The failure mode of equipments will vary, ranging from simple causes such as wear caused by a long period in service with frequent operation, to items which have suffered severe damage. In the latter case there will be an element of salvage involved in the overhaul process. The equipment will be supplied in an 'as found' condition after being removed from its working position on the railway.

The service life of this equipment is 15 years. The shelf life is 3 years.

A general view of a P&LD Box is shown in Figure A.

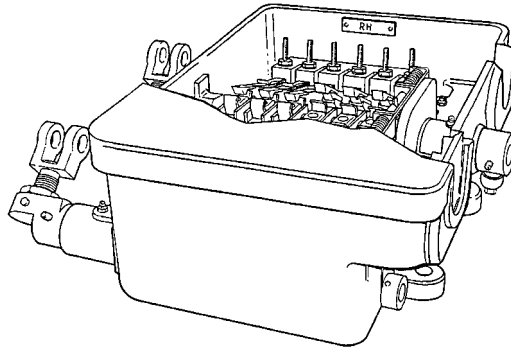


Fig. A General view of a 6-way P&LD Box

6. Usage of item

The P&LD Box is a component part of a 4' and 6' point layout. It is used to detect that the points have fully thrown (closed switch rail is against the stock rail to within an acceptable limit and the open switch rail has opened to a predetermined position) and that the point lock has been fully inserted into the locking bars.

Detection of the switch positions is accomplished using rotary cams operated by two radial arms one of which is attached to the tip of each switch. Each cam lifts or lowers a set of spring contacts depending on the position of each switch. In the lowered position each contact may make with a moving bridge contact if the bridge contact is itself in the correct position.

On 4' point layouts, the switch locking dabs are fitted to the escapement. On 6' point layouts the switch locking dabs are fitted to the Lock Slide Casting. Detection of the point lock is therefore different on the different layouts although the same principle is used in each case. A linear cam path is cut in the escapement blade or the lockslide blade and this is used to alter the position of the moving bridge contacts referred to in the previous paragraph. A ball follower is used to detect the linear position of the slide bar. The bridge contacts may be in a Normal, Reverse or a mid position.

4 or 6 sets of contacts are provided in the different styles of box. The cams and bridging contacts are arranged so that half of the contacts are closed when one switch rail is detected as closed and the Normal lock dabs are detected as engaged. The other half of the contacts are closed when the other switch rail is detected as closed and the Reverse locking dabs are detected as engaged.

7. Equipment design outline

Design features built into the P&LD Box include:

- Construction that is designed to be, as far as is practicable, ultra reliable in operation
- Construction designed to resist the considerable vibration forces to which it will be subjected throughout its working life
- An ability to configure a left-hand or right-hand configuration from the same component count by fitting components into different positions
- An ability to re-furbish the main wearing components without the need to scrap the major components.



The basic method of operation is identical for both 4-way and 6-way boxes. As the names suggest, the 4-way boxes have 4 independent sets of contacts, configured from 2 groups of 2 contacts each. Likewise a 6-way box comprises two groups of 3 contacts.

P&LD Boxes are 'handed', where a Left Hand unit is mounted on the left hand side of the negative rail when the points are viewed looking into the open ends of the switch rails. Similarly, a Right Hand box is mounted on the right hand side of the negative rail when the points are viewed looking into the open ends of the switch rails.

A 'Fixed Parabola' version is configured from the same component count as regular handed versions with the addition of a fixing plate and associated components to hold the parabola ball in one fixed, offset, position.

8. Applicability

This specification applies to the following items.

Item	Stores List No.
P&LD Box – 6-way (Left Hand)	11-S-203
P&LD Box – 6-way (Right Hand)	11-S-204
P&LD Box – 6-way (Fixed Parabola)	11-S-38
P&LD Box – 4-way (Left Hand)	11-S-205
P&LD Box – 4-way (Right Hand)	11-S-206
P&LD Box – 4-way (Fixed Parabola)	11-S-207

The Illustrated Parts List and accompanying figure, Attachment 2 to this document, forms part of this specification.

9. Critical functions

Critical Functions of the P&LD Box are defined to be:

Ultra-reliable Operation: The equipment has been designed to be a highly reliable item which will work in a hostile environment where it is mounted on the track-bed and therefore subject to high levels of vibration and shock loadings. Elements contributing to high reliability include the secure fixing of cams and other components to their operating shafts (achieved by use of split taper pins), and the secure tightening of locking nuts and other securing devices.

High Structural Integrity of Lifting Cams: Substantial cams are used to lift the contact sets to open the contacts when the Radial Arms are not in their correct positions to close the detection circuits.

Self-centring ability of the Contact Shaft: The Contact Shaft is provided with a self-centring mechanism which is required to drive the Contact Shaft to a mid position in the event of a breakage of the parabola lever. In the mid position all circuits shall remain open circuit.

High Integrity of electrical insulation associated with all contact parts: Insulation between circuits and between open contacts is relied on in the design of the signal system. Failure of insulation of contacts, when the mechanical inputs to the box demands it, will be treated as a wrong-side failure.

Electrical Safety. Satisfactory earthing and bonding of the P&LD Box is crucial to ensure that leakage paths to the case or other extraneous metalwork in the event of faults do not give rise to electric shock hazards or to a loss of vital system integrity.



The ability of the item to meet the critical functions listed above throughout its life depends on many factors, not all of which are immediately obvious to people not familiar with all aspects of the design, overhaul and use of the equipment. To ensure that the significance of certain of the detailed requirements is understood and complied with, a number of Critical Parameters or Settings have been designated throughout the text.

Attachment 3 to this Specification lists all the Critical Parameters or Settings [CPS], a reference to the section from which the requirement originates and provides a Criticality Rating of the importance of each CPS item.

The Criticality Rating is based on the severity of the consequence if there is a deviation of the subject parameter from the value specified. Numerical values have been assigned to various levels of the Criticality Rating (CR) according to the table below.

Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
10	Life critical – sole dependence Occurrence of this deviation alone may lead to an incident causing death or injury.	
8	Life critical – shared dependence Occurrence of this deviation, together with a second deviation which is potentially latent (i.e. not self announcing), may lead to an incident causing death or injury.	
7	Life critical – contributory Occurrence of this deviation increases the probability of an event which may lead to an incident causing death or injury.	Service critical – sole dependence Occurrence of this deviation alone may lead directly to an incident causing major service delays, and indirectly to the danger of a life threatening incident through enforced use of manual rules for operating the railway.
6		Service critical – shared dependence Occurrence of this deviation, together with a second deviation which is potentially latent (i.e. not self-announcing), may lead directly to an incident causing major service delays, and indirectly to the danger of a life threatening incident through enforced use of manual rules for operating the railway.
5		Service critical – contributory Occurrence of this deviation, increases the probability of an event which may lead to major service delays, and indirectly to the danger of a life threatening incident through enforced use of



Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
		manual rules for operating the railway.
1	Not life critical	Not service critical

The criticality rating provides a scale of the importance of achieving the specified parameter and therefore of the care needed in designing the process or processes that will lead to the parameter being achieved. The design of the process or processes that will lead to the parameter being met are the responsibility of the Contractor and they shall be designed and documented in accordance with the requirements of Engineering Standard 1-202, Signalling equipment overhaul.

10. Performance parameters

Performance parameters applicable to P & LD Boxes are defined and quantified below.

10.1 Contact resistance

Contact resistance shall be measured with 0.1 Amp flowing through the contact fed from a 100 V A.C. supply.

The Contact Resistance calculated from the volt drop measured between terminal pairs on opposite Terminal Blocks (items 1-5) of closed contacts shall be no greater than 0.3 Ω .

10.2 Insulation resistance

The insulation resistance, measured between each closed contact pair and the box, shall be greater than 10 M Ω when measured at 1000 V DC.

The insulation resistance between any item forming part of the contact arrangement and any other metallic part of the equipment shall be greater than 10 M Ω when measured at 1000 V DC.

10.3 'Make' and 'Break' positions for contacts

The operating points for the make and break positions of the contacts shall be set using test equipment built in accordance with drawing DS6393. The use of this equipment is detailed in section 13.1.6 of this specification.

11. Equipment configuration

An Illustrated Parts List is provided as Attachment 2, comprising an itemized list and an exploded assembly drawing to describe the equipment as identified in Section 8 of this specification. The Illustrated Parts List contains all relevant drawing numbers.

Separate Illustrated Parts List references are provided for the 4-way and 6-way items although many of the components are common to both versions. All references are related to only one common figure which has therefore been identified as Figure 1/Figure 2.

Figure 1/Figure 2 in the Illustrated Parts List is drawn showing a Right Hand version of a 6-way box. A Left Hand version may be configured from an identical parts inventory by assembling the Bridge Contacts (items 1-16) in a different orientation on the Contact Shaft (1-27).

A Fixed Parabola unit is always biased in the same direction and may be built from the standard components with the addition of an extra Parabola Plate (1-41a) and associated fixings.



A convention of using the figure number followed by the item number has been adopted in this document to uniquely refer to specific components where necessary. Thus, item 1-1 is the Box for a 6-way unit.

Unless specifically noted, drawings and figures used in this Specification are for reference only.

12. General requirements

12.1 Compliance with specification

No departures from the requirements of this Specification shall be permitted (either permanently or temporarily) without compliance with the relevant change control procedures.

Neither equivalence of process nor substitution of materials shall be recognised by the Client in receiving work performed against this specification. The Client shall have the immutable expectation that equipment overhauled to this version of the specification shall be 100% compliant with the specification herein.

12.2 Workshop environment

There are no special conditions associated with the overhaul work detailed in this specification.

Calibrated test equipment shall be used to carry out all measurements specified.

12.3 Calibre of staff

Any staff involved in the overhaul process shall be competent in the tasks they carry out and the overhauling contractor shall demonstrate this in accordance with the requirements of Engineering Standard 1-203, Competence of personnel working on signal and control systems.

12.4 Operator accountability

Process control documentation is required to be completed by identified certified (stamp-holding) operators and inspectors throughout the overhaul process. Each certified operator and inspector shall possess a uniquely numbered stamp which is traceable to the owner. Only competent operators shall be provided with a stamp. Records of the issue and withdrawal (if appropriate) of every stamp shall be kept and shall be made available to the Client on request. The retention period of these records is required to be indefinite.

13. Overhaul definition

The text in this section is written to describe the overhaul of a 6-way equipment and hence component identities given are for the 6-way item. Except where specifically mentioned any reference may be directly converted to the 4-way item number by changing the component pre-fix from a '1' to a '2'.

The 'Front' of the box refers to the end fitted with the radial arms and the 'Rear' of the box refers to the cable entry end.

13.1 Full overhaul

A full overhaul will be performed on items which generally will have been in service for their full routine service life, or which will have been removed from service as a result of a failure.

No item returned after failing in service shall be overhauled until the failure report has been reviewed and accepted by the Client in accordance with a defined arrangement agreed with the Client.

Unless stated to the contrary, all processes detailed in this specification shall be performed for each overhaul.

13.1.1 Dismantle

The P&LD Box shall be dismantled in a manner that shall not damage or shorten the life of any component that is required to be re-used. The life of all recyclable components is indefinite.



The items listed below shall be discarded and replaced with new items at every overhaul.

Locking Plates	Asset Plate	Aeronuts
Lubricating Nipples	Split Pins	Taper Pins
Cam Roller Bearing Screws (1-44)	Rotary Contact pieces (1-16)	Rotary Contact Fixing Screws (1-19)
Rocker Arm Tip (1-30a)	PVC Sleeving (1-39)	Felt Lubricating Pads (1-40)
Rollers (1-43)	Insulating Bushes (1-17)	Insulating Bases (1-18)
Spring Washers (1-15b)	Parabola Ball (1-28b)	Contact Tips (1-11b)

Numbering in the above table refers to the 6-way version. All equivalent parts on the 4-way version, designated as items 2-xx, shall also be discarded.

The items listed below shall be discarded and replaced with items to current design.

Roller Levers not to drawing A2366 (unacceptable items have the threaded stud brazed into the body) (1-28a)	6 Way Rocker Arms not to drawing A48006. (1-30)
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Two screws on the rear internal ledge of the box, which blank holes previously used to fix a single way terminal strip, shall not be removed.

Cams (items 1-51 and 1-52) and Collars (item 1-49) shall be kept together as sets with the shafts (item 1-48) from which they are removed.

Cams (items 1-51 and 1-52), Collars (item 1-49), Radial Arms (items 1-57), Lever Bosses (items 1-55) and Radial Arm Shafts (items 1-48) shall be kept together as sets to allow alignment of taper pin holes at time of re-assembly.

13.1.2 Cleaning

Where specific cleaning agents are not called for, care shall be taken in choosing chemicals which do not leave a residue which may cause adverse effects on the components.

The following shall be implemented after the P&LD Box has been dismantled in accordance with Section 13.1.1 above.

13.1.2.1 All components

All components shall be cleaned and degreased using a technique suitable for that component.

13.1.3 Examination and gauging

All components shall be examined for the effects of excessive or unusual wear, damage caused by misuse and overheating. All occurrences of excessive or unusual wear shall be catalogued and reported to the Client. Signs of electrical tracking or arcing shall be treated as excessive wear.

The subject items of such reports and as much of the unit from which they were removed as possible, shall be saved in their as near as original condition after being discovered and shall be clearly tagged and identified and shall be made available for Client inspection if so desired.



It is critical that **only** those components specified for refurbishment should be reclaimed after failing the wear tolerances specified.

Items not meeting the examination criteria shall be discarded if there is no refurbishment process detailed for it in this Specification.

Major components and items with specific examination criteria are listed below.

All component parts set aside for use in re-assembly shall be to a current approved design. Modification schemes may have been commenced which may not yet have been fully implemented. Units submitted for overhaul may not be to the current build standard. Some components may therefore require to be modified or discarded.

13.1.3.1 General

All oil-ways shall be checked to ensure they are not blocked and that they are clear of material that will damage the bearings, e.g. swarf, grit.

13.1.3.2 Box (Item 1-1)

The general condition of the Box shall be checked. Items shall not exhibit any sign of cracking or damage to the corners.

The distance between the inside faces of the Rocker Shaft bearings, and the relationship between the front face of the Radial Arm bush and the inside of the front Rocker Shaft bearing have in the past been 'standardized'. The distance between the inside faces of the Rocker Shaft bearings will measure 6.500" $\pm$ 0.005". The distance between the front face of the Radial Arm bush and the inside of the front Rocker Shaft bearing will measure 3.687" $\pm$ 0.005" on standardised boxes.

The Box shall have been modified to remove the cast boss previously used to support the Centralising Spring Assembly (item 1-20). See section 13.1.4.2 for details.

The Box shall have been modified to accept detachable wire inlets to drawing DS10576.

The outer edge of the box shall be dressed with a $\frac{1}{16}$ " radius on the full periphery.

The bore of the front Radial Arm Shaft bearings shall not be worn greater than 0.7545" diameter. Items not meeting this criteria shall be fitted with a new bush.

The bore of the rear Radial Arm Shaft bearings shall not be worn greater than 0.567" diameter. Items not meeting this criteria shall be set aside for refurbishing.

The original bore for the front end of the Contact Shaft shall not be worn greater than 1.0045".

Items worn to greater than the given limit may be modified by the fitting of a bush.

If a bush is fitted for the front end of the Contact Shaft, the bore of the bush shall not be worn greater than 0.7545" diameter.

The bore forming the rear Contact Shaft bearing shall not be worn greater than 0.7545" diameter. Replace bush (if fitted) or set aside for refurbishment.

The length of the rear Contact Shaft bearing shall be at least 0.992". Replace bush or set aside for modification to incorporate a bush in accordance with drawing AS26941 as necessary.

The length of the box between thrust faces of both Radial Arm Shaft bearings shall be between 11.0525" and 11.0575". Boxes falling outside this range may be re-furbished as described in section 13.1.4.2 below.

13.1.3.3 Cover (Item 1-2)

No insulating plates shall be fitted to the cover. There shall be no holes in the cover.



Examine the black polyethylene covering for signs of cracking, non-adhesion to cover base material and any other signs of material breakdown. Items with unsatisfactory covering shall be set aside for refurbishing (see section 13.1.4.3).

13.1.3.4 Contact shaft (Item 1-27)

All tapped holes shall have undamaged threads.

The minimum acceptable diameter of the front end of the shaft is 0.9955.

Shafts that have previously been resleeved at their rear end shall be modified as detailed in section 13.1.4.4 below, irrespective of their current diameter.

For Contact Shafts that have not been previously resleeved at their rear end, the minimum acceptable diameter of the rear end of the shaft is 0.746". Shafts with a diameter of less than the acceptable minimum may be refurbished as detailed in section 13.1.4.4 below.

13.1.3.5 Radial arm shaft (Item 1-48)

The minimum acceptable bearing diameter at the rear end of the shaft is 0.746".

The minimum acceptable bearing diameter at the front end of the shaft is 0.559".

Wear is allowed in the tapered holes on the shaft up to a point where the seating is recut to the maximum allowed for the use of a $\frac{7}{32}$ " taper pin.

13.1.3.6 Cams (Items 1-51 and 1-52)

Cams shall be examined as matching assemblies with the shafts onto which they have been or will be fitted.

Cams shall be a push fit onto their shaft with no signs of movement between the cam and the shaft when a taper pin is inserted. A taper pin shall fit into the tapered hole with no sign of movement. Taper pin seatings may be refurbished, as detailed in section 13.1.4.7 below.

The working surface of the cam shall be smooth and undamaged.

The minimum acceptable radius of the low section of the cam is 1.430".

The minimum acceptable radius of the high section of the cam is 1.492".

13.1.3.7 Terminal block (Item 1-5)

The Terminal Block shall be checked for evidence of cracking. Any cracked or otherwise damaged items shall be discarded. Items showing signs of electrical tracking or breakdown of the insulation shall be treated as having excessive or unusual wear and shall be handled in accordance with the requirements of section 13.1.3 of this Specification.

13.1.3.8 Components of contact assemblies (Items 1-10, 1-12, 1-13 and 1-14)

Plating and general condition of components shall be assessed. Damaged components shall be replaced with new. No peeling or worn plating is acceptable.

13.1.3.9 Rocker arm spindle (Item 1-33)

The diameter of the Rocker Arm Spindle shall be measured at all bearing positions along the length of the component. At these positions the minimum acceptable diameter is 0.372".

13.1.3.10 Rocker arm (Item 1-30)

The general condition of the component shall be assessed. There shall be no cracking or distortion of the component.



The maximum acceptable diameter of the bore for the Radial Arm Shaft is 0.3795". Items worn beyond this limit may be refurbished as detailed in 13.1.4.9 below.

Acceptable 4-way components shall be in accordance with drawing A48966 or to a previous design modified in accordance with drawing BS28592.

When the recessed faces machined into the ends of the contact lifting fingers are made to sit on a reference surface which is aligned parallel to the bore of the Radial Arm Shaft, the gap between the highest machined face in any lifting finger and the measuring surface shall be no greater than 0.015". Items not meeting this criteria shall be set aside for refurbishment as described in section 13.1.4.9 below.

13.1.3.11 Roller lever (Item 1-28a)

The Roller Lever shall be a push fit in its Contact Shaft and there shall be no movement between the two components when a taper pin is inserted into the securing hole.

The minimum acceptable diameter of the bearing surface for the Parabola Ball is 0.3710".

13.1.3.12 Radial arm (Items 1-57)

Holes for the link pins shall be gauged for wear. The maximum acceptable diameter is 0.629". Holes may be rebushed as described in section 13.1.4.10 below.

13.1.4 Refurbishment

The refurbishment processes specified below are not necessarily required to be applied to all items. Refurbishment may or may not be required, dependent on the outcome of the examination stage of the overhaul. Some processes, however, are required to be applied to all items, e.g. paint finishes.

No process other than those detailed in this section shall be applied to any component. It is not permitted to reclaim worn or otherwise unacceptable components except by processes detailed here-in.

13.1.4.1 Paint finishes

The items listed below shall be painted in accordance with the painting process specified in this section.

DESCRIPTION	ITEM No.
Box	1-1
Lever Boss	1-55
Radial Arm	1-57

Painting of the Box shall be done after the item has completed any refurbishing required. The Lever Bosses and Radial Arms shall be painted after assembly onto their respective Cam Spindles. The threaded portion of the Radial Arm and the locknut securing it shall be painted.

Each item shall be painted with a base coat of Red Oxide Primer (manufacturer- Hadfields, reference 1313.006) – LU Part No. 17412/429, followed by a top coat of General Purpose Aluminium Paint to LT Specification 174-27 – LU Part No. 17450/225.

All bearing surfaces, threads, oil-ways and operating faces shall be protected from paint application, except where otherwise stated.