



(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 Style N Circuit Breaker Box which are used 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):

CB	Circuit Breaker
CPS	Critical Parameter or Setting
DCN	Design Change Notice
LU	London Underground
OEM	Original Equipment Manufacturer
WSL	Westinghouse Signal Limited

4. Definitions

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 refers to the organisation responsible for the delivery of overhauled equipment.

5. Introduction

This specification has been written to detail the overhaul requirements of Style 'N' Circuit Breaker Boxes which are used in the signalling system on the London Underground.

The Style 'N' Circuit Breaker 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. They have been designed to be ultra reliable pieces of equipment whose mechanical and electrical integrity will be relied on throughout its extended working life. It is a mandatory requirement that a Circuit Breaker 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 allows a Circuit Breaker Box to close a contact when the mechanical conditions dictate that the contact should be open, 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 usually will have failed in service although some may be in working order. The failure mode of items 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 style N9 (4-way), N15 and N16 Circuit Breaker boxes are shown in Figures A, B & C respectively.

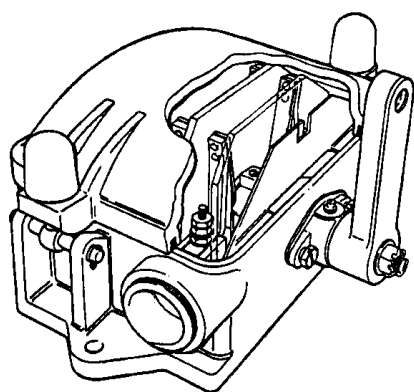


Figure A N9 C.B. Box

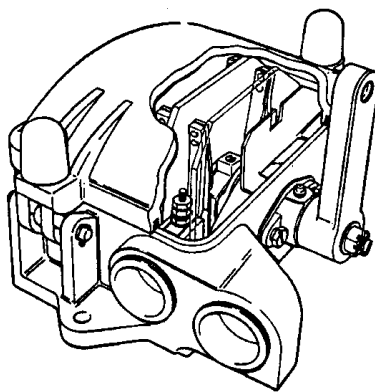


Figure B N15 C.B. Box

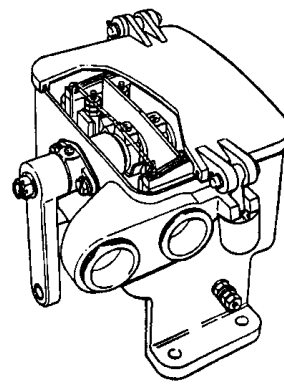


Figure C N16 C.B. Box

6. Usage of item

Style N Circuit Breaker Boxes exist in three styles, designated as styles N9, N15 and N16. All versions covered by this specification are 4-way units. N9 Boxes were also produced as 2-way units but they have been withdrawn over the years to the point where the population is considered too small to be covered by this specification.

The use of Circuit Breaker Boxes is currently mainly confined to their use in depots to detect the status of depot points and other miscellaneous items of equipment. Some use is made of Circuit Breaker Boxes on running lines where they are used to detect the status of flood-gates.

All current variants have four independent sets of contacts, configured to be two sets of 'ON' contacts and two sets of 'OFF'. This terminology originates from the use of Circuit Breaker Boxes to detect the state of Trainstops and is still used today where it can be found in some of the design documentation. Although not truly applicable to today's usage of the items, it is used throughout this document to reflect the usage in the design documents and past custom and practice.

7. Equipment design outline

Design features built into the Circuit Breaker Boxes include:

- Construction that is designed to be ultra reliable in operation
- An ability to re-furbish the main wearing components without the need to scrap major items.

Two independent pairs of 'ON' contacts and two independent pairs of 'OFF' contacts are provided, all worked from a common shaft. The shaft is rotated by the Operating Lever which is connected to the item of equipment being detected by the Circuit Breaker Box.

Each pair of contacts consist of two phosphor bronze springs with keepers. Each contact spring is fitted with a nickel plated contact tip.

Oil retaining bearings are used throughout with each bearing being equipped with a lubrication nipple to ensure adequate lubrication is provided throughout an extended service life.

8. Applicability

This specification applies to the following items.

Item	Stores List No.
N9 Circuit Breaker Box (4-way)	14-S-3
N15 Circuit Breaker Box	11-S-55
N16 Circuit Breaker Box Long Over-arm	11-S-273
N16 Circuit Breaker Box Long Under-arm	11-S-199
N16 Circuit Breaker Box Short Over-arm	11-S-225
N16 Circuit Breaker Box Short Under-arm	11-S-208

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

9. Critical functions

Critical Functions of the Circuit Breaker Boxes 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.

High Integrity Electrical Switching Properties: Although not to a fail-safe design, the electrical contacts are designed to be ultra-safe in breaking the currents to which they are subjected. The mechanical integrity of the components of the contacts is paramount in achieving the desired performance from the equipment. The component parts of the contacts and their attachment to the box requires to be to the highest standard achievable.

Electrical Safety. Satisfactory earthing and bonding of the Circuit Breaker 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.



Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
		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 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 the CB Boxes are defined and quantified below.

10.1 Contact resistance

Contact Resistance shall be measured with between 0.1 and 1 Amp (AC or DC) flowing through the contact. The Contact Resistance calculated from the volt drop measured between terminal posts of closed contacts shall be no greater than 0.05Ω.

10.2 Insulation resistance

The Insulation Resistance between any item forming part of the contact arrangement and any other metallic part of the equipment shall be greater than 50 MΩ when measured at 1000V DC.

11. Equipment configuration

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

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 1-33 is the Shaft.

Component differences between variants is signified by a letter suffix associated with the component. Thus, an N9 Box (1-1a) will use all suffix 'a' items where a choice exists.

N9 and N15 Boxes are very similar in appearance and construction and so they are both referenced from figure 1 of the parts list. The major difference between the two styles is in the Box where the N9 has only one cable entry compared to the two of the N15. Figure 2 is used for all variants of the N16 where the only

component difference in all four versions is the Operating Arm. Two Woodruff Key positions are provided on the shaft allowing both Over-arm and Under-arm variants to be configured using one shaft type.

Other variants of the above listed configurations may be required. They shall be dealt with as 'special order' items.

All references to components in the following text are given with respect to an N9 or N15 item. When applied to an N16 item the component prefix will change from '1' to '2'.

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 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

13.1 Full overhaul

A full overhaul, including repair or replacement of failed component(s) will be performed on each item returned to the workshop.

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 Circuit Breaker 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.

Asset Plate (1-47)	Split Pins (all)	Washers (all)
Oilite Bushes (1-29)	Oilite Bushes (1-31)	Bush (1-25)
Rubber Protectors (1-5)	Lubricating Nipples (1-32)	Woodruff Key (1-34)
Contact Springs (1-54)	Contact Mounting Blocks (1-21)	Contact Pieces (1-19 & 1-20)
Insulating Bushes (1-18)	Contact Tips (1-55)	Nuts (all)
Gasket (1-3)	Standard Screws (all)	

Bent Plates (items 1-13 & 1-14) in N9 & N15 style boxes shall not be removed from the box unless they are damaged and need replacing.

13.1.2 Cleaning

The following shall be implemented after the unit has been dismantled in accordance with Section 13.1.1 above.

All components shall be cleaned and degreased using a technique suitable for that component. A 'suitable technique' shall not cause short term or long term degradation to the component and shall not leave undesirable residues on the component which will affect the performance of the component when it forms part of an overhauled unit.

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. Signs of electrical tracking or arcing shall be treated as excessive wear.

All occurrences of excessive or unusual wear shall be catalogued and reported to the Client. 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.

All component parts shall be examined to see that they are to an acceptable design. Modification schemes 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 Box (Item 1-6)

The general condition of the Box shall be checked. Items shall not exhibit any signs of cracks or have damaged corners.

The top face of the box shall be flat and unbroken sufficient to allow the rubber gasket to form a good seating between the box top and the Cover (1-2).

13.1.3.2 Shaft (Item 1-33)

Existing Shafts to Westinghouse drawing A19526 (N16 Boxes only) may be re-used if in good condition. All new Shafts shall be as detailed in the Parts List.



The Shaft shall be straight to within the manufacturing tolerance and free from evidence of severe rust pitting. The threaded ends of the shaft shall be in good condition and free from rust damage.

The tapered end of the Shaft shall be in good condition and shall provide a positive fit into the tapered bore of an operating arm. The Woodruff Key seat shall provide a good fit for a new key.

The bearing surfaces shall be unpitted. The minimum acceptable diameter of the small end is 0.495". The minimum acceptable diameter of the large end is 0.745".

13.1.3.3 Operating Arm (Items 1-24)

The tapered bore in the Operating Arm shall be capable of providing a secure fit onto the tapered portion of a Shaft (item 1-33).

The maximum acceptable bore of the link pin hole is 0.628". Items not meeting this criteria shall be refurbished as detailed in section 13.1.4.3 below.

13.1.3.4 Bearing Housings (Items 1-28 & 1-30)

Threads for 1/4" BSF lubricating nipples (item 1-32) shall be in sound condition to accept the nipples.

All lubrication channels shall be clear.

13.1.4 Refurbishment

13.1.4.1 Front Bearing Housing (Item 1-28)

New Oilite bushes (item 1-29) shall be pressed into place at each overhaul. Before fitting the bushes they shall have been soaked in a general purpose 10W grade oil for 24 hours.

A 1/8" diameter hole shall be drilled through the new Oilite bush (item 1-29) at lubricating nipple position. Any burrs shall be removed.

13.1.4.2 Rear Bearing Housing (Item 1-30)

A new Oilite bush (item 1-31) shall be pressed into place at each overhaul. Before fitting the bush it shall have been soaked in a general purpose 10W grade oil for 24 hours.

A 1/8" diameter hole shall be drilled through the new Oilite bush (item 1-31) at lubricating nipple position. Any burrs shall be removed.

13.1.4.3 Operating Arm (Item 1-24)

Items may be converted for use with a bush (item 1-25) at the link pin end by press fitting a Phosphor Bronze bush in accordance with drawing AS27007 item 24.

For items already bored to accept a bush, a new bush shall be pressed into place at each overhaul.

13.1.4.4 Paint finishes

The Box (item 1-6) with Bent Plates (items 1-13 & 1-14) already attached, and the Operating Arm (item 1-24) shall be painted in accordance with the painting process specified in this section.

Painting shall be done after the item has completed any refurbishing required.

Both parts shall be painted all over with the exceptions listed below.

Paint application shall be 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, seating faces, threaded holes and operating faces shall be protected from paint application.

13.1.4.5 Contact Spring Assembly (Items 1-38)

Contact Spring and Contact Keeper shall be dismantled from the Support Bracket. Contact Spring with its Contact Tip shall be discarded in accordance with Section 13.1.1.

Contact Keeper shall be plated.

New Contact Spring shall be fitted with a new contact tip in accordance with AS25708.

New Contact Spring (complete with new Contact Tip) and plated Contact Keeper shall be secured to the Support Bracket with rivets (1-58).

Contact Spring Assembly shall be in accordance with drawing AS25708.

13.1.5 Assembly criteria

13.1.5.1 Mechanical assembly

Oilite Bushes shall be fitted to Front & Rear Bearing Housings in accordance with Drawing AS34862.

'ON' & 'OFF' Contacts shall be configured onto the Shaft in accordance with Figure D below. They shall be fitted in accordance with the appropriate General Arrangement drawing as detailed in the Illustrated Parts List. [CPS01]

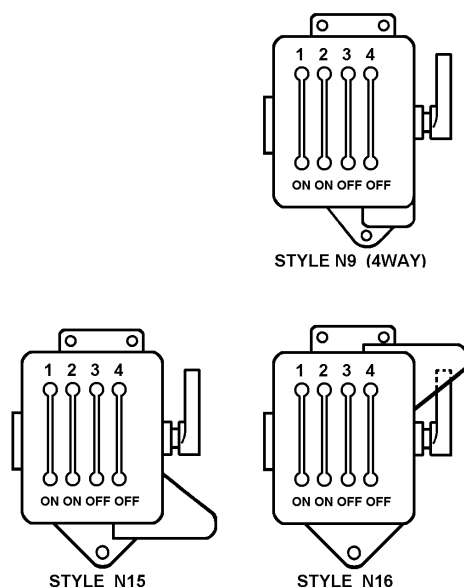


Figure D - Configuration of Contacts

Screws (items 1-17) securing the 'ON' & 'OFF' Contacts shall have Loctite Screwlock 222 (or approved equivalent) compound applied to the thread before being securely tightened. All excess compound shall be removed immediately after tightening. [CPS02]