



(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 Time Element Relays (Style LT) 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

4. Definitions

The Client – The Client is the Infraco 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.

A Front Contact – A front contact provides a very low resistance (short circuit) electrical connection between two terminals of the relay when the relay is in an energised state.

A Back Contact – A back contact provides a very low resistance (short circuit) electrical connection between two terminals of the relay when the relay is in a de-energised state.

5. Introduction

This specification has been written to detail the overhaul requirements of Time Element Relays (Style LT) which are used in the signalling system on the London Underground. These relays are known as LT JR's within the business and that term will be used throughout this document.

The LT JR is classified as an item of vital signalling equipment which means that it may be used in the safety-critical circuits directly affecting the safe movement of trains. It has been designed to fail-safe principles and manufactured to exacting tolerances to ensure that it fulfils its safety role throughout a very extended life. It is a mandatory requirement that a relay 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 relay.

Any failure condition which causes the relay to behave as though

- any front contact is closed when the specified voltages required to energise the relay are not present
- any front and any back contact are closed simultaneously,
- any contact or coil has an electrically conductive path to any other contact or coil, or
- the full time delay will not be achieved at the next operation of the relay

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 open circuit contacts, 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 10 years. The shelf life is 3 years.

A general view of a LT JR is shown in Figure A.

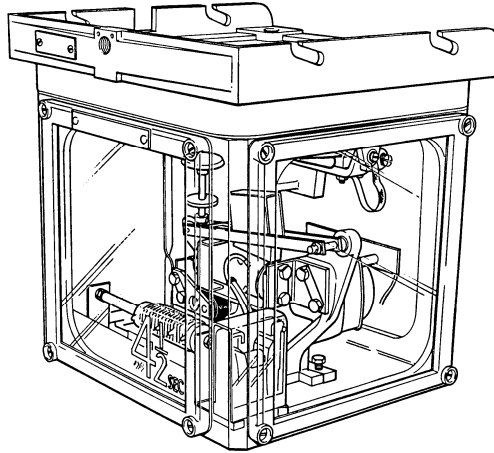


Figure A General view of a LT JR Relay

6. Usage of item

The LT JR is designed to provide a delay between applying the energizing voltage to the pick-up terminals and the closing of the relay's front contacts. They are used in safety-critical circuits where train speed restriction is necessary. Speed restriction is achieved by delaying the clearing of a signal by a set time (the relay timing period) which will ensure the train speed is lower than the acceptable safe speed for the prevailing site conditions. An example of where train speed restriction is necessary is the entry of a train into a terminal station. To comply with the fail-safe design criteria of the equipment it must never operate in less than its designed time delay period. Operation in greater than the design time period, or failure to operate at all, will not compromise the safety of the railway.

Train speed detection is accomplished by the use of a short 'timing' track circuit. The time of occupancy of the timing track is compared with the timing period of the Time Delay Relay. If the timing track circuit is occupied for longer than the period of the timing relay then the train is deemed to be travelling at less than the required speed and the signalling circuits will operate in the appropriate manner. If the timing track is not occupied for long enough, signifying a train going faster than the signalling has been designed for, then the signal circuit will operate as appropriate for handling an over-speeding train.

The design of the relay has taken into account the high integrity that is expected from the item. Accordingly it is a large piece of equipment which seemingly is doing a very simple task. However, every aspect of the design has a direct influence on the safety of the item and therefore on the safety of the London Underground train service.

The design of the signalling system is based on fail-safe principles and hence the regular and expected failures (wires breaking, fuses blowing, loss of power supply, high resistance or open circuit contacts, relays not energising, etc.) do not cause dangerous situations to arise.

Four variants of the LT JR are in current use, being designed to operate on $33\frac{1}{3}$ Hz or 125 Hz and with time delays of $4\frac{1}{2}$ seconds or 15 seconds. All variants have three front contacts and two back contacts. Additionally a back proving contact is provided which signifies that the timing mechanism has returned to its fully reset position. The operating frequency and the fact that it is a time delay relay is colour coded into the colour scheme for the case and window frames. A keyed peg is fitted to the relay top frame to ensure that only relays of the correct time setting are fitted into the fixed wiring at the signal site.

7. Equipment design outline

Key design features of all LT JR's are that they have been designed to include:

- Construction that is designed to be, as far as is practicable, fail-safe in operation
- Jewelled bearings for the contact carriage, the proving carriage and the proving arm
- A combination of contact materials, pure carbon and silver, that are non-weldable
- An operating mechanism that only responds to AC energisation
- A fail-safe timing mechanism that is keyed to the frequency of the supply used to energise the relay
- A timing mechanism that resets to the full time period, and is proved to have done so, if there is an interruption to the applied energisation voltage

The LT JR uses an A.C. induction motor to drive a gear chain which lifts the drive arm to a position where it will trip a magnetic toggle. The gear train drives a rubber friction roller. A serrated drive armature is held in contact with the drive roller by a solenoid which is energised by the input voltage applied to the relay. The drive armature is driven at a controlled maximum speed and at the end of its stroke, and hence after the defined time delay, it trips the magnetic toggle which operates the contact carriage. The magnetic toggle ensures that the contact carriage changes its position from de-energised to energised in a short period during which the back contacts will open and the front contacts will close.

An internally wired back contact is used to control the voltage to the timing motor. Thus the relay may be continuously energised with the motor only running during the timing period.

An independent contact carriage carries the proving contact. This contact is only closed when the timing mechanism is in its reset condition and ready to start a full timing cycle. It therefore opens very shortly after the relay starts to energise. The proving contact is used by the external signal circuits to control the energisation of the relay, proving that it has returned to its fully reset position after the last energisation before being re-energised.

All contacts are standard silver/carbon contact pairs as used on other safety signal relays.

Gravity, alone, is used to return the relay to its de-energised condition. The resetting of the timing mechanism is accomplished by the fall of the drive armature from a fully or partially energised position. Therefore, the mechanical movement of all parts of the assembly is designed to be as frictionless as is practical. Jewelled bearings are used for the contact carriage and proving contact carriage pivots. All linkages have been designed to be easily visible and as simple as possible.

Key sensitivities in working on these relays are:-

- The correct motor and gearbox combination must be fitted to achieve the desired time delay
- The diameter of the moulded rubber drive wheel is critical to the timing period
- The formulation and hardness of the moulded rubber drive wheel is critical to the life and long term reliability of the relay and also to its ability to drop away when the input voltage is removed
- Free movement of the main contact carriage, proving contact carriage and proving arm is essential for the safe operation of the relay and hence all jewelled bearings must be treated with the utmost care

8. Scope

This specification applies to the following relay variants:-

Item	Stores List No.
100 volt 33 ¹ / ₃ Hz 4½ second Time Delay Relay	55s33
100 volt 125 Hz 4½ second Time Delay Relay	55s161
100 volt 33 ¹ / ₃ Hz 15 second Time Delay Relay	55s331
100 volt 125 Hz 15 second Time Delay Relay	55s162

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

9. Critical functions

Critical Functions of the LT JR are defined to be:

Fail-safe Operation: The equipment has been designed and manufactured with the underlying premise that the relay shall not energise before the designed time delay period has elapsed. The mechanism must return to its reset state immediately it is de-energized even if the timing sequence has not completed.

High Integrity Electrical Insulation: All electrical wiring and insulating components shall maintain their integrity throughout the life of the equipment. No failure mode shall be allowed to compromise electrical isolation between any part of any circuit within the equipment.

Non-weldability of contacts: The contact materials are specified to be a pair of materials (silver and pure carbon) that have been proven to have a very low probability of welding. The composition of the carbon contact is critical to maintain this design goal.

Freedom from mechanical binding. The design of the relay has taken into account the need for the timing mechanism and the contact carriage to return to its fully de-energised position when demanded by a lack of input voltage throughout an extended service life. To this end, agate bearings are employed in all critical positions and all linkages have been kept simple. Clearances between components have been kept as large as practical and in most cases can be visually inspected from outside the relay when it is in its operating position.

High Reliability: The relays have been designed to be highly reliable and this reliability is relied on in providing the scheduled train services. Failed equipment may need to be exchanged during traffic hours which may involve staff being on the track as trains move past them. The safety of passengers can become an issue when trains are delayed in tunnels as a result of failed equipment.

Electrical Safety. Satisfactory earthing and bonding of the relay 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, a reference to which of the Critical Functions is dependent on each CPS item 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.	



Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
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 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 each of the four relay variants are defined and quantified below.

10.1 Operating voltage

The nominal Operating Voltage for all variants is 100 volts A.C., being the voltage applied to terminals R1 and R2 to cause the relay to commence its timing function.

The Minimum Operating Voltage for all variants is 80 .0 volts.

The Maximum Operating Voltage for all variants is 110.0 volts.

10.2 Time delay period

The Time Delay Period, measured in seconds, is defined as the period between applying the input voltage to the energising terminals, R1 and R2, and the front contacts closing.

The Time Delay Period shall be as defined in Table 1 below.

	Time Delay Period
33 ¹ / ₃ Hz 4½ second	4.5 +10% - nil seconds
125 Hz 4½ second	4.5 +10% - nil seconds
33 ¹ / ₃ Hz 15 second	15.0 +10% - nil seconds
125 Hz 15 second	15.0 +10% - nil seconds

Table 1 TABLE OF TIME DELAY PERIODS

10.3 Contact resistance

The contact resistance, when measured at a contact pressure of 40 – 45 grams and with between 0.1 and 1 Amp (AC or DC) flowing through the contact, shall be less than 0.5Ω.

10.4 Insulation Resistance

The insulation resistance between all parts of the electrical circuits and the case of the relay shall be at least 50 MΩ when measured at 1000V DC.

The insulation resistance between any parts of insulated circuits shall be at least 50 MΩ when measured at 1000V DC.

11. Equipment configuration

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

Drawing CS13427 details the terminal configuration of the detachable top for each type of relay. This drawing shall be used to configure the relay terminals with the exception of the earth terminal shown on the drawing, which shall not to be fitted to any relay. All unused terminal positions shall be fitted with blanking plugs (item 2-90).

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 1-49 is the relay case.

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

A number of operations associated with the overhaul of the LT JR relay are sensitive to the ingress of airborne dust and other contaminants, particularly into the jewelled bearings used in the relay. Therefore any operation or process in which '*inspected bearings*' are present, either as individual components or as part of a sub-assembly, shall be carried out in a '*clean*' environment.

An '*inspected bearing*' is defined to be a Jewelled Bearing Assembly, a Contact Carrier Pivot, a Proving Contact Carrier Pivot or a Proving Lever Pivot which has passed the final stage of inspection before being used to build up a sub-assembly. To meet the requirement of the previous paragraph it is therefore necessary to inspect the bearings within a clean area.

The silver and carbon contacts are also sensitive to contamination from handling. The carbon contacts are prone to absorb grease and soap residues from the skin if touched with bare hands. Lint-free protective gloves shall be worn by operators when handling carbon and silver contacts.

A '*clean*' environment is defined to be an area, with defined boundaries, inside which no food or drinks are allowed and no contaminants are generated or are allowed to circulate. A contaminant may be generated by filing, sanding, sawing, cleaning or any other similar operation.

Contaminants shall not be allowed to enter the environment from the surroundings through the airflow from unsuitable conditions

An acceptably clean environment shall not contain

- unsealed walls (bare brickwork)
- high ceilings with rafters, beams and light fittings with the potential for the build-up of dust which cannot be easily removed by regular cleaning during shut-down hours
- windows opening into other areas or the outside environment
- through passage routes between other uncontrolled areas

Once a sub-assembly becomes subject to clean area handling it shall not leave the clean area except that it be sealed in a clean transportation container or the relay is complete with all glasses fixed in position.

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

13.1 Full overhaul

A full overhaul will be performed on relays 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.

Two types of rectifier are currently in service – a 'Westalite' selenium rectifier and a potted silicon diode bridge type. The 'Westalite' selenium type is being replaced by the potted bridge type. The conversion involves the plugging of two fixing holes in the case and the drilling and taping of the case to accept the new design of rectifier bracket.

Three types of motor are currently in service – Walter Jones, Garrard and Evershed and Vignolls. **All** relays are now to be fitted with the Walter Jones type motor. There is therefore an ongoing but diminishing requirement to convert incoming relays containing Garrard and Evershed and Vignoll type motors to the latest build standard.

13.1.1 Dismantle

The relay 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.

Hammers and other percussion tools shall not be used during the dismantling process of any assembly still containing jewelled bearings.

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

Top Gasket	Window Gaskets (all)	PVC Glass Seals (all)
Spade Terminals (all)	Locking tabs (all)	Locking wires
Contact Braids (all)	Earth Braids	Carbon tips (all)
Internal Wiring	Rectifier (item 1-39)	Washers – all
Aeronuts (all)	Nuts – all	Link Pins (all)
Screws – all (except motor fixing screws)	Drive Roller (part of friction drive assembly)	Locating Plate (4½ sec.) (item 3-138)
Lead Securing Clips (items 1 –21)	Spring Fork Arm (2-73)	

The items listed below shall be discarded and replaced with equivalent items as specified in the detailed parts listing.

Selenium Rectifiers (replace with item 1-39)	Resin filled breather discs (replace with item 1-51)	Aluminium Top Frames (replace with item 1-08)
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The jewelled bearing assemblies shall be removed from the relay as complete units. They shall be put aside for gauging and inspection.

The bearing assemblies shall be stored and transported in specially designed containers to ensure no damage is caused to the components throughout the overhaul process. The container shall be constructed of materials which are not susceptible to static electricity to prevent the attraction of dust and other light fibrous material from the atmosphere. No fibrous material shall be used in the construction of the container. The bearing assemblies shall be stored open end downwards to prevent dust or other material from entering the bearing. The containers shall be fitted with dustproof lids which shall be kept in place at all practical times.

The impact detector shall be removed from the relay as a complete unit. No further dismantling is required.

The Bottom Bearing Bracket (item 1-33) and the Adjusting Screw Bracket (item 1-35) shall not be removed from the case.

If fitted, two blanking screws and washers (items 1-43 and 1-44) shall not be removed from the case.

The Clutch Magnet and Yoke Assembly (item 3-141) shall be removed from the Motor Support Casting (item 3-104) as a unit complete with Yoke Support Bracket (item 3-145) and not dismantled any further until it has been examined and its condition assessed.

The Motor and Gearhead (item 3-106A/B/C/D) shall be removed from the relay as a complete unit and not stripped any further. The leads leaving the motor housing shall not be cut but shall be unsoldered in such a way that they may be re-used without the need to extend them.

The Carbon Posts shall not be removed from the Top Plate at the time of stripping.

The Pivot Pin (item 3-152) shall not be removed from the Motor Support Casting (item 3-104) at the time of stripping.

13.1.2 Cleaning and stripping

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 nor shall any solvent used leave undesirable residues on the component which will affect the performance of the component when it forms part of an overhauled unit.

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 inside the relay during their service life. The carbon contacts are sensitive to contamination by a number of chemicals which can affect them even in a vapour phase.

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

13.1.2.1 Top Frame, Main Case and Window Frames

Components shall be cleaned and stripped back to bare metal using a process that ensures complete removal of all existing paint without causing damage or degradation to the component. Particular attention shall be paid to the preservation of thread forms.

13.1.2.2 Other metallic components

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

13.1.2.3 Jewelled bearings

Jewelled Bearings within the bearing assemblies shall be cleaned and degreased by soaking in a solution of Bioplex 500, or other equivalent approved substance, for one hour before thorough rinsing in clean water followed by thorough drying off before the assembly is inspected prior to re-use.

13.1.2.4 Top plate

The Bakelite top plate shall be cleaned and degreased.

13.1.2.5 Glass

Glass from the side frames shall have any labels removed before being cleaned and dried to remove any residue.

13.1.2.6 Impact detector

After removing the transparent cover and the weight, the impact detector shall be lightly cleaned using an air-line, soft brush or other similar technique.

13.1.3 Examination and gauging

All components shall be examined for the effects of excessive or unusual wear, general damage, damage caused by misuse or age, electrical arcing or tracking or overheating. All thread forms shall be checked for signs of over-tightening. Items exhibiting damage that will not be corrected by the specified re-furbishing processes shall be discarded.

All occurrences of excessive or unusual wear or damage 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 Relay case (Item 1-49)

The stripped case shall not exhibit any signs of damage or cracking.

Tapped holes shall be checked for damage to threads. All holes shall have serviceable threads.

A check shall be made of the blanking discs, (eyelet with disc, item 1-51) for tightness and soundness. Replace loose or damaged items with new.

13.1.3.2 Contact carrier bearing assembly (Item 2-57), Double ended screw bearing (Item 2-88), Bearing screw (Items 1-28)

The external surface of housings shall be examined for signs of wear or damage. No housing shall exhibit any signs of wear or damage.



The diameter of barrel jewels shall be gauged to be within the limits of 0.0950" to 0.0970". [CPS01, CPS02 and CPS03]

Using a Mantis 3-D microscope or other equivalent instrument equipped with a suitable light source and holder for the bearing being examined and having a magnification of at least 6 times, examine the barrel jewel and endcap jewel. No cracks, chips, scoring or other evidence of wear shall be visible. The bearing shall be checked to ensure it is free of any foreign objects particularly dust, fibre hairs or any other item. [CPS04, CPS05 and CPS06]

Assemblies exhibiting any chip, crack, score or sign of wear are not acceptable.

13.1.3.3 Contact carrier and pivot pins (Items 2-59 and 2-61), Proving contact carrier and pivot pins (Items 2-60 and 2-61)

All items shall be checked for signs of cracking or physical damage. No item shall exhibit cracking or physical damage.

Items with plating that is corroded or peeling may be re-plating.

Pivot Pins shall be securely fitted to carrier. If either pivot pin is loose, both pins shall be replaced.

Existing carrier pivot pins need not be replaced if they meet the gauging requirements but all replacements are to be to latest style as identified in the Parts List.

Pivot Pins shall be examined for signs of wear. Surface shall be free of scratches and scoring. The minimum diameter of each pin shall be 0.0910" measured across three diameters approximately spaced 120° from each other. [CPS07 – CPS08]

If either pin fails to meet the minimum diameter, set aside for re-pinning. Pivot Pins shall be replaced as pairs.

13.1.3.4 Proving lever spindle bearing (Item 1-28)

The Pivot Pins shall be examined for signs of wear. The surface shall be free of scratches and scoring. The minimum diameter of each pin shall be 0.0910" measured across three diameters approximately spaced 120° from each other. [CPS09]

If either pin fails to meet the minimum diameter, the item shall be discarded.

13.1.3.5 Contact spring (Items 2-64)

The Contact Assembly shall be examined for signs of distortion or fatigue. Distorted or fatigued items are not acceptable.

Where Contact Tips exhibit severe pitting, burning or evidence of melting, the tips shall be replaced. Where light pitting only is evident, the Contact Assembly may be re-used after refurbishment of the tip.

13.1.3.6 Clutch magnet armature (Item 3-133)

The hole in the Clutch Magnet Armature shall be gauged to be within 0.1250" – 0.1263". [CPS10]

Examine plating of the component and replate as necessary if existing plating is corroded, flaking or in an otherwise unsatisfactory state.

The profile of the Armature shall be gauged in accordance with the procedure given in drawing AS46621 using a jig in accordance with drawing AS31522. [CPS11]

13.1.3.7 Armature link (Item 3-151)

Two patterns of the Armature Link are in service. The original item is in accordance with drawings AS27947 and AS26594. Items to this design may be re-used if they meet all the gauging requirements. If original pattern items fail the wear gauge they shall be rebushed in accordance with drawing AS27947.



New items are to be in accordance with drawing AS26594.

Items which have corroded or flaking plating shall be replated.

The guide horn shall be securely hard soldered to the arms in accordance with drawing AS26594.

The pivot pin bearing hole shall be gauged to be within the limits of 0.1875" – 0.1900". [CPS12]

Items with holes not meeting the gauging requirements shall be rebushed to bring the item into accordance with drawing AS27947.

13.1.3.8 Friction drive assembly (Items 3-123 or 3-131)

The gear wheel of the assembly shall be examined for wear. Renew gear wheel if it shows signs of wear.

The bearing surfaces of shaft shall be examined. The minimum acceptable diameter of the shaft is 0.1860". The bearing surface shall not be scored or damaged.

Acceptable units are to be put aside for replacement of the drive roller (all units).

13.1.3.9 Proving carriage arm (Item 2-100)

The condition of the plating of the component shall be examined. Items with worn or peeling plating shall be discarded or replated.

The link pin hole shall be gauged to be within limits of 0.099" – 0.101". [CPS13]

13.1.3.10 Proving lever (Item 1-27)

Examine the condition of the plating of the component. Items with worn or peeling plating shall be discarded or replated.

The link pin hole shall be gauged to be within limits of 0.099" – 0.101". [CPS14]

13.1.3.11 Twisted link (Item 1-17)

The condition of the plating of the component shall be examined. Items with worn or peeling plating shall be discarded or replated.

Both link pin holes shall be gauged to be within limits of 0.099" – 0.101". [CPS15]

13.1.3.12 Spring fork arm (Item 2-73)

New Spring Fork Arm to be fitted at every overhaul.

13.1.3.13 Motor and gearhead (Items 3-106 A/B/C/D)

The motor leads shall be checked over their whole length for damage to insulation. Motors with damaged leads or with leads of insufficient length to reach their points of connection shall be discarded.

The torque of the Motor and Gearhead shall be tested with 80 volts applied to the motor in accordance with drawing AS31523. [CPS17]

13.1.3.14 Motor support casting (Item 3-104A/B/C/D)

Items with corroded or peeling plating shall be replated.

The bearing holes for the Friction Drive Assembly, Idler Gear and Compound Gear shall be gauged to dimensions given in the table below. [CPS18]

BEARING IDENTITY	DIMENSION
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Friction Drive Assembly	0.1875" – 0.1890"
Idler Gear	0.1250" – 0.1265"
Compound Gear	0.1250" – 0.1265"

The Pivot Pin (item 3-152) shall be firmly riveted to the casting. The diameter of the Pivot Pin shall be within the range 0.184" – 0.187" at the two areas of contact of the Armature Link (item 3-151). [CPS19]

13.1.3.15 Bearing plate (Item 3-124) - 4½ second relays only

Two patterns of Bearing Plate are in circulation. The current part is to drawing AS53789. Items not to this drawing are to have the $\frac{7}{16}$ " hole added.

Items with corroded or peeling plating shall be replated with a bright Nickel finish. Bearing holes shall not be plated.

The bearing hole for the Friction Drive Assembly shall be gauged to be within limits of 0.1875" – 0.1890". [CPS20]

13.1.3.16 Bearing plate (Item 3-131) - 15 second relays only

Items with corroded or peeling plating shall be replated with a bright Nickel finish. Bearing holes shall not be plated.

The bearing holes for the Friction Drive Assembly, Idler Gear and Compound Gear shall be gauged to dimensions given in the table below. [CPS20]

BEARING IDENTITY	DIMENSION
Friction Drive Assembly	0.1875" – 0.1890"
Idler Gear	0.1250" – 0.1265"
Compound Gear	0.1250" – 0.1265"

13.1.3.17 Compound gear (Item 3-129) – 15 second relays only

The item shall be examined for corroded or flaking plating. The item shall be stripped and replated as necessary.

The item shall be discarded if the gear is worn or otherwise damaged.

The bearing journals shall be gauged to the limits of 0.1225" – 0.1242". [CPS21]

The bearing surfaces shall not be scored or damaged.

13.1.3.18 Idler gear (Item 3-130) - 15 second relays only

The item shall be examined for corroded or flaking plating. The item shall be stripped and replated as necessary.

The item shall be discarded if the gear is worn or otherwise damaged.

The bearing journals shall be gauged to the limits of 0.1225" – 0.1242". [CPS22]

The bearing surfaces shall not be scored or damaged.

13.1.3.19 Clutch magnet and yoke assembly

Examine the coil for signs of overheating. The Empire cloth binding shall be tightly wound and the coil connecting tags shall be firmly attached to the coil.

The alignment of the pole faces of the core and yoke shall be checked to be in accordance with drawing AS27464.

The insulation resistance between the coil and the yoke shall be checked to be in accordance with section 10.4.

13.1.3.20 Capacitor (Items 1-20A/B)

The insulation resistance between each terminal of the capacitor and the case shall be checked to be in accordance with section 10.4.

The capacity of each capacitor shall be measured on a bridge. The value shall be as given in the table below.

NOMINAL VALUE	MINIMUM VALUE	MAXIMUM VALUE
2 μ F	1.9 μ F	2.1 μ F
5 μ F	4.75 μ F	5.25 μ F

13.1.3.21 Impact detector

A check shall be made for signs of corrosion on the contact spring (item 4-173) and the weight (item 4-180). The Contact Spring shall be discarded if corroded and replaced with new spring complete with rivets. The Weight shall be stripped and re-plated, or discarded, if corroded.

13.1.4 Refurbishment

13.1.4.1 Paint finishes for painted items.

All paint used shall be air drying, suitable for spray application. Products used shall be suitable for the material to which they are applied and shall be compatible with other paint products applied above or below them. It is a particular requirement that no paint applied to the inside of the relay shall flake off any surface to which it has been applied over the whole life of the relay.

13.1.4.1.1 Top Frame (Item 1-8A/B/C/D)

All surfaces shall be painted with one coat of undercoat over bare metal. One topcoat of black gloss to be applied to all surfaces over the undercoat.

13.1.4.1.2 Case (Item 1-49)

The flexible cable retaining clips (items 1-21) shall not be painted. Masking shall be attached before the undercoat is applied and removed after the topcoat has dried.

Neither face of the horizontal part of the Adjusting Screw Bracket (item 1-35) shall be painted. Masking shall be attached before the undercoat is applied and removed after the topcoat has dried.

Neither face of each of the vertical parts of the Bottom Bearing Bracket (item 1-33) shall be painted. Masking shall be attached before the undercoat is applied and removed after the topcoat has dried.

No flaking paint is acceptable. The finish of the inside of the relay case is required to be to the highest standard with no runs or accumulation of paint which could dry out and peel or craze during an extended life



at high temperatures. Adhesion of all coats to the base metal and each other is a crucial factor to the safety of the relay.

All surfaces shall be painted with one coat of undercoat over bare metal.

One topcoat of white gloss shall be applied to all surfaces except the bottom, over the undercoat.

The final coat shall be a gloss coat, colour coded to requirements of drawing BS14224, applied to the four vertical external faces of the case.

It is permitted to use external masking plates to prevent the top colour coding coat from entering inside the relay case. Masking plates for the sides of relay shall be smaller than the outline of the window frame to prevent any white base coat from showing when the relay is assembled with the window frames.

For cases previously fitted with the now obsolete Westalite selenium rectifier, a new style rectifier bracket shall be fitted in accordance with drawing CS64450.

13.1.4.1.3 Window Frame (Items 1-2 and 1-2A)

Frames shall be spray painted on all surfaces with one coat of undercoat followed by one gloss topcoat, colour coded to requirements of drawing BS14224.

13.1.4.2 Motor support casting (Item 3-104A/B/C/D)

The Motor Support Casting shall be stripped and replated to the original manufacturing specification. Plating shall be removed from the holes used as bearings for the Friction Drive Assembly, and the Compound Gear and Idler Gear on 15 second variants.

13.1.4.3 Friction drive assembly (Items 3-123 or 3-131)

The Drive Roller (item 3-123A or 3-131A) shall be replaced at each overhaul.

A new Drive Roller shall be fitted and after re-assembly the surface of the Drive Roller shall be ground to dimension in accordance with drawing AS43145.

13.1.4.4 Contact carrier and pivot pins (Items 2-59 and 2-61), Proving contact carrier and pivot pins (Items 2-60 and 2-61)

Carriers may be stripped and re-plated after removing the pivot pins. Pins shall be replaced with two new pins as below.

Pins shall be replaced in pairs using new pins. Pins are to be fitted to carrier using tool J2838.

13.1.4.5 Contact assembly (Items 2-64)

Tips with a flattened surface which cannot be restored to a cylindrical form shall be replaced with a new tip with a finish at least as good as the refurbished tip described below.

The silver contact tip shall be lightly dressed using a flat 10000 grit whetstone lubricated with water before being burnished on a hard flat leather strop loaded with jewellers' rouge. All residue from these processes shall be thoroughly cleaned off the component.

It is important to maintain a cylindrical form to the silver contact tip. A domed or spherical form to the contact tip is not acceptable.

13.1.4.6 Bearing plate (4½ second) (Item 3-124)

Items not to drawing AS53789 shall have the $\frac{7}{16}$ " diameter hole added provided bearing holes have been gauged as satisfactory. The items shall be stripped and replated after hole has been added.

13.1.5 Assembly criteria

This section covers the common assembly requirements of all variants. The exact configuration requirements are as detailed on section 11.

Final adjustments and settings, some of which are common to all variants and others are specific to particular variants, are described in section 13.1.6.

All soldered joints shall be inspected to ensure that they are correctly formed. The joints shall be marked to show that they have been inspected. Marking shall be with a benign permanent substance which will not adversely affect the soldered joint. An example of a suitable product is the Berol Autoseal Ink Toughpoint Permanent Marker, Colour – Red. [CPS 61]

The Case shall be cleared of paint to provide a bright metal surface to ensure good electrical continuity between the Earth Braid connection and the Case.

The counterbores for the fixing screws in the Top Frame (item 1-8A/B/C/D) shall be cleared of paint to provide a bright metal surface to ensure good electrical continuity between the Top Frame and its fixing screws (items 1-9).

13.1.5.1 Impact detector (Item 4-167)

Each Impact Detector shall be adjusted using a Drop Tester to Drawing DS26302. The Impact Detector shall be adjusted so that, when used on the Drop tester it does not trigger when tested at a height of less than 1" but does trigger when tested at a height of 1½". [CPS23]

The gap between the Spring (item 4-173) and Impact Detector Body (item 4-172) shall be a minimum of 0.010".

13.1.5.2 Contact carrier and contact assemblies

All the silver tips of the Spring Contacts (items 2-64) shall have been refurbished to the requirements of section 13.1.4.5. New contact tips shall have a surface finish at least as good as that specified in that section. [CPS24]

Each Contact Insulator (item 2-63) is fitted to the Contact Carrier (item 2-59) using a locking plate (item 2-69) and 2 BA full nuts (item 2-70). Each nut shall be tightened to a torque of 15 lbf.in. In cases where the Insulator stud is too short to protrude completely through a nut then a half nut (not identified in parts list) may be substituted provided the stud protrudes through the half nut. If the stud does not protrude through the half nut then the Contact Insulator shall be scrapped. [CPS25]

The length of all Braids (Items 2-67) shall be 1¾" before forming and soldering. Apart from the length required to form the solder joint at the end attached to the Contact Spring (items 2-64) they shall not be stretched over any part of their working length.

It is imperative that all braids shall be positioned in accordance with Drawing 7034-A1-109153 maintaining at least ½" clearance in all directions around each braid. [CPS26]

13.1.5.3 Proving contact carrier and contact assembly

The Proving Contact Carrier shall be assembled in a similar manner to that described in section 13.1.5.2. The Proving Carriage Arm shall be attached at right angles to the axis of the Carrier. Clearance between the contact braid and the bearing support plates shall be at least ½". [CPS27]

13.1.5.4 Top plate assembly

The Top Plate (item 2-52) shall be configured in accordance with drawing CS13427.