

(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 2 Position Gravity Biased Relays 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. Reference

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
SEV	Single Element Vane

WSL Westinghouse Signal Limited

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.

Normal – Normal refers to one of the two positions which a point layout may take in which a train may safely be authorised 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. The term is also applied to signify the position of the lever which controls the movement of the points.

Reverse – Reverse refers to one of the two positions which a point layout may take in which a train may safely be authorised 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. The term is also applied to signify the position of the lever which controls the movement of the points.

5. Introduction

This specification has been written to detail the overhaul requirements of the Gravity Biased 2 Position (Style BG) Relays, hereafter referred to as a 'BG relay', which are used in the signalling system on the London Underground.

The BG Relay is classified as an item of vital signalling equipment which means that it may be used in the most critical safety circuits directly authorising the 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

- it had been energised, when the voltages required to energise it had not present
- any front and any back contact are closed simultaneously, or
- any contact or coil has an electrically conductive path to any other contact or coil,

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.

A general view of a BG Relay is shown in Figure A

Items supplied for overhaul will be complete units which may be in working order or may have failed in service. The failure mode of items 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.

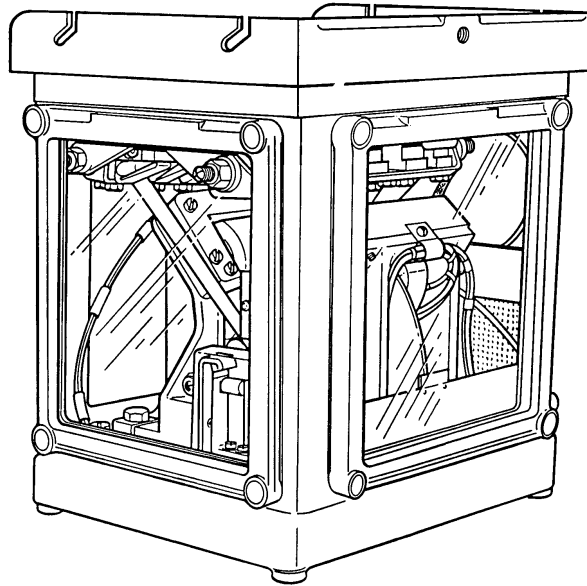


Figure A. Gravity Biased 2 Position (Style BG) Relay - General View

6. Usage of item

BG relays are used in the control circuits of points, to provide partial route releases in special circumstances and to control single line working. In all cases the ability to remain in its last known position, even after restoration of power following a power failure, is a crucial characteristic of BG relays. Each operation of the relay is proved to have taken place after which it is assumed the relay will not change its state until commanded to do so by energisation of the opposite control winding.

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, etc.) do not cause dangerous situations to arise.

Two variants of the BG relay are in current use, being designed to operate on $33\frac{1}{3}$ Hz or 125 Hz. Both variants have six Normal contacts and six Reverse contacts. Each variant has its own unique colour scheme for the case and window frames.

7. Equipment design outline

Key design features of all BG relays 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 both the vane spindle and the contact carriages
- A combination of contact materials, pure carbon and silver, that are non-weldable
- An operating mechanism that only responds to AC energisation

The BG relay is operated by two eddy current vane motors, similar in principle to that used in the SEV relay, which are positioned to oppose each other and operate on a common vane. The vane is mounted so that it has two stable positions, one either side of an unstable equilibrium position. This is achieved by making the vane pass above its spindle through a 'top-dead-centre' position when moving from one stable position (Normal) to the other stable position (Reverse). Using this configuration enables the Normal or Reverse contacts to remain closed even after the energising voltage has been removed.

Energisation of the relay is accomplished through two separate pairs of terminals, each pair being connected to a pair of coils mounted on independent iron circuits. The Normal coils are arranged to drive the vane into its Normal position, the Reverse coils drive the vane into the Reverse position.

There is no defined 'de-energised' position for a BG relay. It is designed to remain in the last position to which it was driven.

Two contact carriages are used to provide 6 independent Normal and Reverse contacts. Each contact pair comprises a fixed pure carbon contact and a pure silver armature. The mechanical linkages driving the contact carriages is designed to prevent both Normal and Reverse contacts from making at the same time.

Due to the higher vane speed of the 125 Hz version there is a need to control the speed of operation to prevent excessive forces being generated on the jewelled bearings and end stops. For this reason a series diode has been introduced into each of the control windings. The diode introduces a D.C. component to the current flowing in the coils. This D.C. current provides an eddy current braking effect on the vane as a result of the vane's movement.

8. Scope

This specification applies to the following relay variants.

Item	Stores List No.
33 ¹ / ₃ Hz BG Relay	55-S-63
125 Hz BG Relay	55-S-158

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

9. Critical functions

Critical Functions of the BG Relay are defined to be:

Fail-safe Operation: The equipment has been designed and manufactured with the underlying premise that the Normal and Reverse contacts will never be closed simultaneously. Also it is assumed that the relay will not change its state except when a valid input is applied to the input terminals associated with the newly required state with no input applied to the coils of the current state. These prime functions of a BG Relay are supported by other detail requirements which are also critical functions and are also detailed in this list.

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 insulation between any part of the contact arrangement of 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 when used correctly. The composition of the carbon contact is critical to maintain this design goal.

Defined minimum operate voltage: The application of the equipment in signalling circuits relies on the relay not energizing if it is supplied with less than the specified minimum operate voltage. The operate voltage is, to some extent, dependent on the mechanical integrity of the equipment. It is therefore vitally important that balance weights, or any other component that can have the effect of being a balancing component, are securely and reliably fixed in their correct operating position.

Electrical Safety. Satisfactory earthing and bonding of the BG 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 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	Service critical – sole dependence Occurrence of this deviation alone may lead directly to an incident causing major service

Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
	an incident causing death or injury.	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

All performance parameters given in this section are applicable to both $33\frac{1}{3}$ Hz and 125 Hz relays.

10.1 Minimum 'operate' voltage (V_{op})

The Minimum Operate Voltage is defined as that voltage which, when applied to one pair of input terminals of the relay, when there is no voltage on the opposite input terminals, just causes the relay to change state. Separate parameters are recognized for Normal to Reverse and Reverse to Normal operation.

$V_{op(N \rightarrow R)}$ and $V_{op(R \rightarrow N)}$ shall be in the range 65.0 to 70.0 Volts.

10.2 Contact resistance

The contact resistance, when measured at a contact pressure of 71 grams ± 3 -0 grams (nominally 2½ oz.) and with between 0.1 and 1 Amps (AC or DC) flowing through the contact, shall be less than 0.5Ω.

10.3 Insulation resistance

The Insulation Resistance measured between all terminals connected together and any other metallic part of the relay shall be at least 50MΩ when measured at 1000 V D.C.

The Insulation Resistance measured between any part of independent circuits shall be at least 50MΩ when measured at 1000 V D.C.

11. Equipment configuration

An Illustrated Parts List is provided as Attachment 2, comprising a common itemized list and associated exploded assembly drawings. 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 1-2 is the relay case.

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 be fitted to any relay. All unused terminal positions shall be fitted with blanking plugs (item 2-39a).

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 BG relay are sensitive to the ingress of airborne dust and other contaminants, particularly into the three pairs of jewelled bearings used in each 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 or vane shaft pivot or a contact carriage 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 buildup 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 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 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 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 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)
Internal Wiring	PVC Spacer (item 1-6a)	Link Pins (all)
Diode (125 Hz only)	Locking tabs (all)	Locking wires
Contact Braids (all)	Earth Braid	Vane arm links (items 3-95 and 3-96)
Carbon tips (all)	Cable Clips (item 1-21)	Aeronuts (all)
Screws – (all)	Nuts – all	Washers – all
Spade Terminals (all)		

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

Aluminium Top Frames	Resin filled breather discs	
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The Coil(s) shall not be removed from their iron system until they have been examined and their condition assessed.

The Operating Arm shall not be removed from the Contact Carrier until they have been examined and their condition assessed.

The Vane Assembly shall not be dismantled but shall be put aside for gauging and inspection as a complete unit. The Vane Assembly shall be stored and transported in specially designed containers to ensure no damage is caused to the components throughout the overhaul process.

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.

13.1.2 Cleaning and stripping

The following shall be implemented after the relay 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 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.

13.1.2.1 Top Frame, Main Case, Case Extension 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.

All traces of gasket material shall be removed from the joint between the two parts of the case.

13.1.2.2 Other metallic components

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

13.1.2.3 Jewelled bearings

Jewelled bearings within the main and contact carrier bearing assemblies shall be cleaned and degreased by soaking in a solution of Bioplex 500, or approved alternative solution, for one hour before thorough rinsing in clean water followed by thorough drying 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 Vane

The surface of the vane shall be cleaned using a **non**-abrasive cleaner or solvent. No residue shall remain on any part of the assembly. Any previous inspection stamp shall be completely removed.

13.1.2.6 Glass

Glass from the window frames shall be cleaned and dried to remove any residue.

13.1.2.7 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 at 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 components (Item 1-2 and 2-74)

The stripped case components (items 1-2 and 2-74) shall be examined for signs of damage or cracking. No cracking is acceptable.

Tapped holes shall be checked for damage to threads. No damaged threads are acceptable.

The blanking discs (eyelet with disc, item 2-75) shall be checked for tightness and soundness. Loose or damaged items shall be replaced with new.

Cases with holes that are now no longer used shall be set aside for the holes to be plugged.

13.1.3.2 Main bearing assembly (Item 3-100)

All external surfaces of housing shall be checked for signs of wear or damage. No sign of wear or damage is acceptable.

The diameter of the barrel jewel shall be gauged to be within the limits of 0.0950" to 0.0970". [CPS01]

The barrel jewel and endcap jewel shall be examined 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. 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. [CPS02]

Assemblies exhibiting any chip, crack, score or sign of wear shall be refurbished by fitting new seating washer, endcap jewel and barrel jewel (items 3-100f, 3-100g and 3-100h).

13.1.3.3 Contact carriage bearing assembly (Item 2-43)

All external surfaces of the housing shall be checked for signs of wear or damage. Thread form shall be checked for signs of cracking or over tightening. No housing exhibiting signs of wear or damage is acceptable.

The diameter of barrel jewel shall be gauged to be within the limits of 0.0950" to 0.0970". [CPS03]

The barrel jewel and endcap jewel shall be examined 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. 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]

No Assembly exhibiting any chip, crack, score or sign of wear is acceptable.

13.1.3.4 Vane support casting (Item 3-84)

The casting shall be examined for signs of cracking or corrosion. No cracked or corroded castings are acceptable.

The alignment of the tapped holes for the main bearing assemblies shall be checked using a tool manufactured in accordance with drawing 7034-A3-109157. [CPS05]

The use of any form of cutting tool (tap or reamer) to check alignment of bearing holes is expressly forbidden.

The casting shall be sat on a flat reference surface. The bottom of the 'high' bolting boss shall be no more than 0.005" above the reference plane. Items failing this check shall be set aside for refurbishing. [CPS06]

13.1.3.5 Vane spindle assembly (Item 3-98a/b)

The Vane shall be inspected for signs of cracking, particularly in the area of the rivet holes. No Vanes exhibiting cracking are acceptable.

Pivots that are not to the latest design shall be replaced.

The Pivots of the Vane Spindle Assembly shall be tested for diameter. Each pivot shall have a diameter of not less than 0.0925" when measured in three orientations at approximately 120° apart. [CPS07]

Failure of either pivot to meet the parameter specified in the previous paragraph shall result in both pivots being replaced.

The vane alignment shall be tested using a suitable jig that will ensure the vane is capable of swinging through a gap of 0.038" without touching any part of the test gap. An electrical (continuity) check shall be employed as part of the test rig to detect that the vane does not touch any part of the test gap. The Vane Spindle Assembly shall be cleaned before it is gauged for alignment as described in this paragraph. [CPS08]

The Link Pin holes shall be examined and gauged to be within the range 0.099" – 0.101". [CPS09]

There shall be no burrs in the slot for the Vane Link. Slot width shall be gauged for a minimum width of 0.060". [CPS10]

Each Vane Spindle Assembly that passes all gauging parameters and that is considered fit for re-use shall be marked with an examination stamp in an area that does not enter the iron circuit during any movement of the Vane.

13.1.3.6 Iron core assembly

The iron core assembly shall be removed from the Vane Support Casting before examination.

Coils manufactured before 1990 shall be discarded, otherwise coils in accordance with drawing AS31393 which bear a label identifying them as less than 20 years old may be re-used if they meet all the examination parameters below.

The coils shall be examined for signs of wear (fretting of the tape insulation on the laminations) and overheating. The coil shall not be loose on the laminations. Loose coils may be repacked onto the core provided that there is no damage to outer tape insulation of the coil. The solder tags shall be firmly attached to the coil. The laminations shall not exhibit signs of cracking or flaking of insulated coating and shall not be rusty.

Provided that none of the above conditions are present, the individual iron core assembly may be re-used without further dismantling. If any of the above conditions are present, then the core shall be stripped down and rebuilt using replacement component parts as necessary.

The resistance of each coil shall be measured. Coils shall have a resistance within the range specified on drawing AS31393.

13.1.3.7 Impact detector (Item 1-123)

The Contact Spring (item 5-129) and the Weight (item 5-136) shall be checked for signs of corrosion on. The Contact Spring shall be discarded if corroded and replaced with new Spring complete with rivets. The Weight may be stripped and re-plated if corroded.

13.1.3.8 Contact carriers, Operating arms and Pivot pins (Items 2-47, 2-63, 2-49 and 2-48, 2-62, 2-49)

The items shall be checked to ensure there are no signs of cracking or physical damage.

If plating on Carrier is corroded or peeling, set aside for re-plating.

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

Existing carriage pivot pins may be re-used where they meet the gauging requirements but all replacements are to be to latest style as identified in the Parts List.

Examine pivot pins 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. [CPS11]

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

Check for secure attachment of Operating Arms (items 2-62 or 2-63). Dismantle and re-assemble if either is loose.

The maximum acceptable diameter of the Operating Arm Link Pin holes is 0.101".

13.1.3.9 Contact assembly (Item 2-57)

The Contact Assembly shall be examined to ensure there are no signs of distortion or fatigue.

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.

13.1.4 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 1-10)

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 1-2 and 2-74)

The flexible cable retaining clips shall not 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.

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

13.1.4.1.3 Window Frame (Item 1-3)

Frames are to 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 Case (Item 1-2)

Holes in the case that will not be used at assembly (e.g. hole previously used to support the relay identity label) shall be plugged with a countersunk head iron rivet of an appropriate size for the hole being plugged. The hole shall be lightly countersunk on each side and the rivet riveted into the countersink to secure it. The rivet shall be dressed smooth on each side.

13.1.4.3 Vane support casting (Item 3-84)

The Vane Support Casting shall be lightly shot blasted to remove any tarnish accumulation.

All threaded holes shall be fitted with threaded inserts to prevent the threads in the casting from being damaged during the blasting process.

All blasting residue shall be removed by use of high pressure air-line, or other suitable and efficient means, to ensure no residue can be introduced into the new relay case at, or after, time of assembly.

The underside of the bolting-down bosses may be dressed by hand to produce a flat bolting plane which has the high boss within 0.005" of the true seating plane.

13.1.4.4 Vane spindle assembly (Item 3-98a/b)

Worn pivots (items 3-86) shall be replaced in pairs with new items.

13.1.4.5 Contact carrier and pivot pins (Items 2-47, 2-48 and 2-49)

The Carrier may be stripped and re-plated after removing the pivot pins and Operating Arm. Replace pins with two new pins as below.

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

13.1.4.6 Spring contact assembly (Items 2-57)

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.