



(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 3 position Double Element Vane Relays which are used extensively in the signalling system on the London Underground.

The specification hierarchy that 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
DEV	Double Element Vane
LU	London Underground
OEM	Original Equipment Manufacturer
PCB	Polychlorinated Biphenyl
WKR	Point Indication Relay
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.

A Normal Contact – A Normal contact provides a very low resistance (short circuit) electrical connection between two terminals of the relay when the vane is driven from its neutral (horizontal) position to its raised position.

A Reverse Contact – A Reverse contact provides a very low resistance (short circuit) electrical connection between two terminals of the relay when the vane is driven from its neutral (horizontal) position to its lowered position.

5. Introduction

This specification has been written to detail the overhaul requirements of 3 position Double Element Vane Relays (referred to hereafter as WKRs, the abbreviation used to signify point indication relays, the most common application for this equipment) which are used extensively in the signalling system on the London Underground.

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

- any contact is closed when the specified voltages required to energise the relay are not present
- any Normal and any Reverse 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.

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 that have suffered severe damage as a result of being subjected to the effects of traction currents. In the latter case there will be an element of salvage involved in the overhaul process. The equipment will be returned for overhaul or repair 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 is a side view of a WKR in a partially dismantled condition.

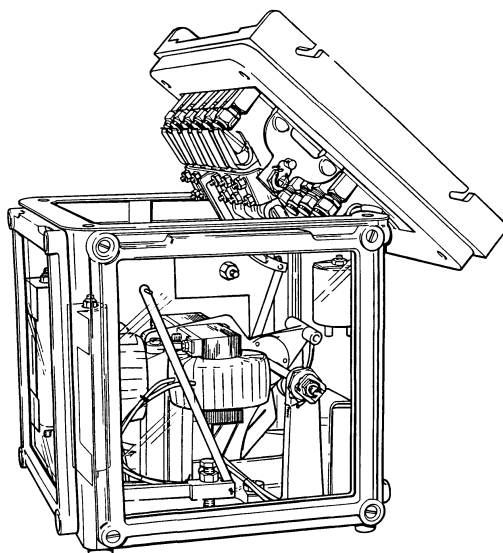


Fig. A. General View of a 3 Position DEV Relay

6. Usage of item

WKRs are used primarily to detect the state of the points which route trains through an area of controlled signalling. A set of points usually lies in one of two positions, referred to as either lying 'Normal' or 'Reverse' where the Normal state is usually associated with the straight through route and the Reverse state is usually associated with the divergent route. Detection contacts in the point mechanisms themselves determine that the points are actually fully closed in one of the two states before a signal is sent to the WKR. The direction of the points (Normal or Reverse) is conveyed to the WKR by the phase relationship of the signal passed to it from the point mechanism. It is therefore imperative that the Normal and Reverse contacts open when the voltage applied to the relay is reduced below the release value and that it energises in the correct direction corresponding to the true position of the points it is associated with.

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

Two variants of the WKR are in current use. One variant is for $33 \frac{1}{3}$ Hz operation and the other is for 125 Hz operation. Both types 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 WKRs 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 carriage
- A combination of contact materials, pure carbon and silver, that are non-weldable
- An operating mechanism that only responds to AC energisation

Like the 2-position DEV, the WKR is a vane relay that uses two sets of coils – the Local winding and the Control winding – to generate the operating torque that energises the relay. The magnetic and electrical circuits form an Eddy Current Vane Motor where rotational (pick-up) torque on the vane is proportional to flux produced by current from both the Local and Control windings. The phase relationship between the Local and Control voltages determines in which direction the vane will be driven. The local winding is fed from a 100 volt reference supply. The control winding is energised via pole-changing detection contacts attached to the point switches, such that the Control voltage is in phase with the Local voltage when the points are lying fully Normal, in anti-phase when the points are lying fully Reverse, and de-energised if the points are in neither state. Both the Local and Control windings operate at 100 volts.

The Control winding comprises two coils on a common magnetic core, connected in series to sum the flux produced by each coil. A capacitor is internally fitted to 125 Hz relays only.

The Local winding comprises two coils mounted on separate cores. The coils are connected to sum the flux produced by each coil.

The purpose of the Auxiliary coils and diodes (125 Hz relays only) is to produce damping of the faster vane movement which occurs at the higher operating frequency, by introducing an element of polarised flux in the magnetic circuit. Coil winding (Local and Control) details also differ between the two operating frequencies.

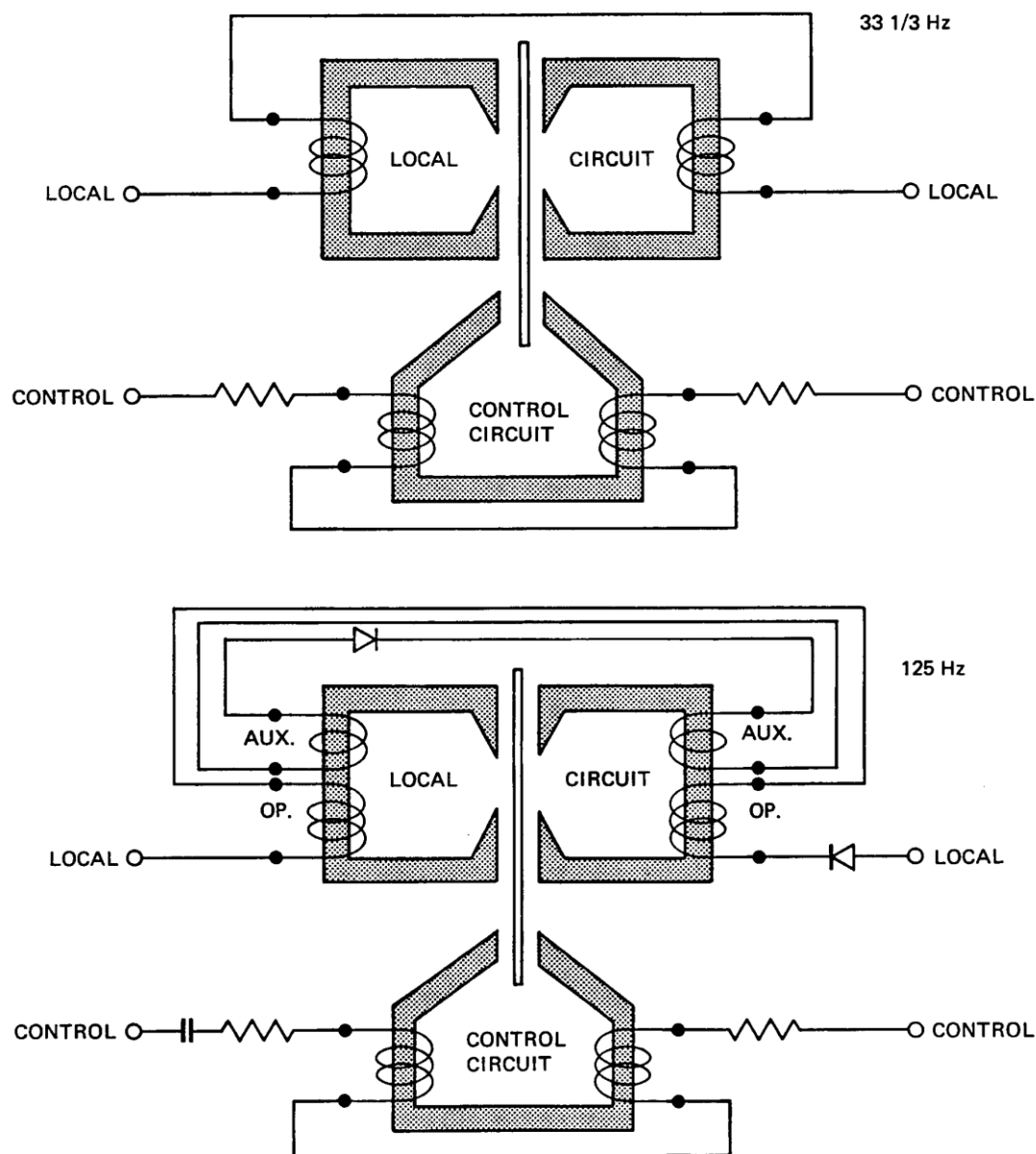


Fig. B Magnetic and Electrical Circuit Arrangements

Figure B shows the magnetic and electrical circuits for 33 $\frac{1}{3}$ Hz and 125 Hz relays.

The torque to move the contact carrier to its energised position is generated by the interaction of magnetic fields acting on eddy currents induced in the vane. Both sets of coils produce approximately equal amounts of flux and eddy currents. Slots are cut into the vane to make the induced eddy currents pass through the magnetic field produced by the control coils.

The vane is made to rest in its de-energised position at the mid-point of its stroke by two weighted arms acting through a pair of lost motion connecting arms. The integrity of the mechanical components of the vane linkage is critical to the safe operation of the relay.

Gravity is relied on to return the relay to its de-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 vane pivots as well as for the contact carriage pivots. The alignment of the shafts and their bearings is critical to keep the mechanism as free-moving as possible. All linkages have been designed to be easily visible and as simple as possible.

8. Applicability

This specification applies to the following relay variants.

Item	Stores List No.
33 $\frac{1}{3}$ Hz WKR	55S13
125 Hz WKR	55S160

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

9. Critical functions and parameters

9.1 Critical Functions

9.1.1 Fail-safe Operation

The equipment is designed and manufactured with the underlying premise that

- a) provided the relay is installed and used in accordance with accepted standards, whenever the relay energisation falls below a defined level, or the currents in the two windings are of incorrect phase relationship, the contacts can be relied upon to open with a very high level of dependability, and
- b) the failure modes of the equipment are highly predictable, and will not prevent the achievement of (a) above.

This prime function of 'fail-safe' operation is supported by other detail requirements, which are also critical functions and are also detailed in this list.

9.1.2 High Integrity Electrical Insulation and switching properties

All parts of the relay's electrical circuits and insulating components are designed to 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, including the isolation between contact poles when the contact is required to be open.

9.1.3 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.

9.1.4 Defined operating points

For the safe and reliable application of the equipment in signalling circuits, its response to electrical inputs must conform to defined limits. The particular operating points for which critical levels of energisation are defined, for both Normal and Reverse energisation, are:

- a) Pick-up all the Normal or Reverse contacts just close



- b) Normal all the Normal or Reverse contacts achieve a minimum acceptable operating pressure
- c) Release all the Normal or Reverse contacts just open
- d) Drop-away the relay counterbalance mechanism returns to its neutral centre position

Of these, (a), (c) and (d) are critical for safety, while (b) is critical for reliability.

Operating point stability is also 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 position.

9.1.5 Integrity when used outside normal conditions

WKR relays are used in circumstances where stray currents from the 600 V DC traction supply may find their way onto the control winding. The relay is designed not to energise when supplied with DC, but the control winding and its wiring may become overheated. Materials used in the construction of the control winding must not outgas any flammable vapour, and wiring for the control winding must not become detached (to prevent the possibility of sparking), even under prolonged overheating.

9.1.6 Freedom from mechanical binding

The design of the relay has taken into account the critical importance of the vane dropping to its de-energised state, freely and without being impeded, throughout an extended service life. To this end, agate bearings are employed for both the vane and the contact carriage and all linkages have been kept simple. Clearances between components have been kept as large as practical and in most cases can be visually seen from outside the relay when it is in its operating position.

9.1.7 High Reliability

The relays have been designed to be highly reliable and this characteristic is essential to the provision of the scheduled train services. Equipment failure may expose maintenance staff to increased risk when the activities of faultfinding or equipment replacement involve trackside access. The safety of passengers can become an issue when trains are delayed in tunnels as a result of failed equipment.

9.1.8 Protection against earth faults (electric shock hazard and loss of vital system integrity)

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

9.2 Critical Parameters or Settings

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.

Note that while a CPS will generally be identified in the discussion of a particular stage of the overhaul, each CPS must be achieved not only at that stage, but also in the completed relay.



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 following table.

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

Values for the voltage parameters applicable to each relay variant are as given in Table 1.

		33 ¹ / ₃ Hz	125 Hz
Pick-up voltage (volts)	V _{p-u}	Not more than 30.0	Not more than 30.0
Release voltage (volts)	V _{rel}	Not less than 60 % of V _{p-u}	Not less than 60 % of V _{p-u}
Normal voltage (volts)	V _n	Not more than 85.0	Not more than 85.0
Drop-away voltage (volts)	V _{d-a}	Not less than 10.0	Not less than 10.0

Table 1. Table of operating parameters

10.1 Pick-up Voltage (V_{p-u})

The pick-up voltage is defined as that voltage applied to the Control winding which, when gradually applied between terminals R1 and R2, with 100 volts applied to the Local Winding, causes all the Normal (or Reverse) contacts of the relay to just close.

Separate pick-up voltages for Normal and Reverse energisation are to be recognised.

10.2 Drop away Voltage (V_{d-a})

The drop-away voltage is defined as that voltage which, when gradually reduced from the Normal value and being applied between terminals R1 and R2 with 100 volts applied to the Local Winding, causes the relay counterbalance mechanism to return to its de-energised position.

Separate drop-away voltages for Normal and Reverse energisation are to be recognised.

10.3 Release Voltage (V_{rel})

The release voltage is defined as that voltage existing across the Control Winding, having been gradually reduced from the normal voltage, with 100 volts applied to the Local Winding, which allows all the Normal (or Reverse) contacts to just open.

Separate release voltages for both Normal and Reverse energisation are to be recognised.

10.4 Normal Voltage (V_{norm})

The normal voltage is defined as that voltage which, when applied to the Control Winding with 100 volts applied to the Local Winding, causes a contact pressure of $\frac{3}{4}$ ounce (21 ± 0.2 grams) to be applied to each of the Normal (or Reverse) contacts.

Separate normal voltages for both Normal and Reverse energisation are to be recognised.

10.5 Contact resistance

The contact resistance, at a contact pressure of $\frac{3}{4}$ ounce (21.3 ± 0.2 grams), shall be such that with between 0.1 and 1 Amps (AC or DC) flowing through the contact, the resistance shall be less than 0.5 Ω.

10.6 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 1000 V DC.

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

11. Equipment configuration

An Illustrated Parts List is provided as Attachment 2 to this document, comprising an itemised list and associated exploded component drawings, to describe both 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 be fitted to any relay. All unused terminal positions shall be fitted with blanking plugs (item 2-169).

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 1-54A is the relay case.

Unless specifically noted, diagrams 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 WKR relay are sensitive to the ingress of airborne dust and other contaminants, particularly into the two 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 that 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.

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

Section 13.1 defines the requirements for 'full overhaul'. An overhaul contract will generally specify a full overhaul for relays which have been in service for a significant part of their planned service life, or which 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, subject to any particular conditions or restrictions defined in this specification.

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.

PVC Glass Seals (all)	(item 1-7)		
Window Gaskets (all)	(item 1-8)		
All Link Pins	(items 1-9, 1-40, 1-41, 3-106)	Spring Stops and fixing screws	(item 3-114,3-115)
Top Gasket	(item 1-14)	Screws – all	
Diode (125 Hz only)	(items 1-21, 1-35)	Nuts – all	
Cable Clips	(items 1-54c)	Washers – all	
Earth Braid	(item 2-61)	Locking wires	
Spade Terminals (all)	(item 2-73)	Aeronuts (all)	
Contact Braids (all)	(item 2-74)	Internal Wiring	
Carbon tips (all)	(item 2-88)	Locking tabs (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	Platform style Vane Support Castings
Platform style Cases	Oil-filled Capacitor (item 1-23a)	Capacitor Bracket (item 1-24a)
Vane Assemblies with cross pinned pivots		

WARNING:

Although no oil-filled capacitors containing PCBs have knowingly been used in WKRs, the handling and disposal of discarded Oil-filled Capacitors should be performed as though they do contain a PCB based oil.

The following components shall not be removed from the relay case at time of dismantling.

Breather Discs – unless resin filled (2 off)	Counterbalance Weight Bracket (2 off) (item 1-37)	Counterbalance Screw Stop (items 1-171) (2 off)
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The Coils making up the Local winding of 33 $\frac{1}{3}$ Hz relays shall not be removed from their iron core assemblies. They shall be put aside for examination while still mounted on their iron core assembly.

The Vane and Spindle Assembly (item 3-102) shall be put aside for examination as a complete unit, although it shall be noted that vane spindle pivots shall be replaced with new items at every overhaul as detailed in 13.1.4.3. 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 cleaning, 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 that 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 present in 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 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 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, particularly in the vane slots. Any previous inspection stamp shall be completely removed.

13.1.2.6 Glass

Glass from the side 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 (Item 1-54a)

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

Tapped holes shall not exhibit any damage to threads.

The blanking discs (eyelet with disc, item 1-54B) shall be checked for tightness and soundness. Loose or damaged items shall be replaced with new.

A check shall be made that the two Counterbalance Screw Stops (items 1-171) are securely fitted and the top surfaces are undamaged. Loose or damaged items shall be replaced with new.

13.1.3.2 Main bearing assembly (Item 3-93)

No external surface of the housing shall exhibit any signs of wear or damage. The thread form shall not exhibit any signs of cracking or over tightening.

The inside diameter of the barrel jewel shall be within the limits of 0.0950 in. to 0.0970 in. [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, at 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 may be refurbished by fitting new barrel jewel, endcap jewel and seating washer (items 3-99, 3-100 and 3-101).

13.1.3.3 Contact carriage bearing assembly (Item 2-55)

Existing Contact Carriage Bearings may be re-used if they pass all examination criteria. All new items shall be as specified in the Parts List.

All external surfaces of the housing shall be checked for signs of wear or damage. The thread form shall not exhibit any signs of cracking or over tightening.

The inside diameter of the barrel jewel shall be gauged to be within the limits of 0.0950 in. to 0.0970 in. [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, at 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 shall exhibit any chip, crack, score or sign of wear.

13.1.3.4 Vane support casting (Item 3-145)

Each Vane Support Casting shall be stamped with a unique serial number in accordance with drawing 7034-A3-109159. This requirement is part of an ongoing upgrade program. Castings with no number shall be numbered as part of the overhaul process. For details of numbering see section 17 of this specification.

The casting shall not exhibit any sign of cracking or corrosion.

In order to ensure that the air-gap in the iron systems is perpendicular to the centre line of the main jewelled bearings, the axis of the main bearing mounting holes shall be checked to ensure it is perpendicular to the centre line of the iron circuit fixing holes. A maximum run-out, measured between the ends of the vane spindle, of 0.008 in. is allowable. Castings which are outside this tolerance may be adjusted to bring them back to within the allowable tolerance provided that the initially measured run-out is less than 0.020 in. [CPS05]

The alignment of the tapped holes for the main bearing assemblies shall be checked using a jig manufactured to drawing 7034-A3-109157. [CPS06]

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

13.1.3.5 Vane and Spindle assembly (Item 3-102)

The Vane shall not exhibit any signs of cracking, particularly in the region of the ends of the slots.

All Vane Spindle Assemblies shall be checked to ensure that the iron slug inside the indicator part of the hub casting is present and is securely fastened.

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 in. 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 diameter of the link pin hole in the vane hub shall not be greater than 0.1012 in. [CPS09]

The slot for the vane link arm shall be checked for burrs. The width of the slot shall be not less than 0.073 in. [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 - Local

For assemblies that are dismantled and re-assembled with new coils, new binder plates shall be fitted to the top and bottom of each stack.

Only coils conforming exactly to drawing BS30721 or BS43109 shall be re-used.

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 their insulating coating and they

shall not be rusty. New laminations shall only be used as complete stacks. Individual rusty or damaged laminations may be replaced by good reclaimed items from other units.

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.

For 33 1/3Hz relays, the resistance of each coil shall be within the range specified on drawing BS30721.

For 125Hz relays, the resistance of each coil shall be within the range specified on drawing BS43109.

13.1.3.7 Iron core assembly – Control

For assemblies that are dismantled and re-assembled with new coils, new binder plates shall be fitted to the top and bottom of each stack.

Only coils conforming exactly to drawing BS29871 or BS43108 shall be re-used.

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 providing that there is no damage to the outer tape insulation of the coil. The solder tags shall be firmly attached to the coil.

The laminations may be re-used provided they do not exhibit signs of cracking or flaking of their insulating coating and they shall not be rusty. New laminations shall only be used as complete stacks. Individual rusty or damaged laminations may be replaced by good reclaimed items from other units.

For 33 1/3Hz relays, the resistance of each coil shall be within the range specified on drawing BS29871. For 125Hz relays the resistance of each coil shall be within the range specified on drawing BS43108.

13.1.3.8 Impact detector (Item 4-146)

Items shall be checked for signs of corrosion on the contact spring (item 4-152) and the weight (item 4-158). Contact spring to be discarded if corroded and replaced with new spring complete with rivets. The Weight may be stripped and re-plated if corroded.

13.1.3.9 Contact carrier and pivot pins (Items 2-79 and 2-79a)

The items shall not exhibit any signs of cracking or physical damage.

If plating 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.

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 in. measured across three diameters approximately spaced 120 ° from each other. [CPS11]

Existing pivot pins may be re-used where they meet all of the above criteria. If either pin fails to meet any of the above criteria, both pins shall be replaced. All replacement pins are to be to latest style as identified in the Parts List.

13.1.3.10 Contact assembly (Items 2-66)

The Contact Assembly shall not exhibit any sign 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.