



(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 Train Speed Detection Relays (style LT) which are used in the signalling system on the London Underground.

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

2. References

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

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

3. Abbreviations

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

CPS	Critical Parameter or Setting
DCN	Design Change Notice
DEV	Double Element Vane
LU	London Underground
OEM	Original Equipment Manufacturer
SRBF	Synthetic Resin Bonded Fibre
WSL	Westinghouse Signals Limited

4. Definitions

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

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

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

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 the Train Speed Detection Relay, Style LT which are used in the signalling system on the London Underground. The relay is also referred to as a 'Frequency Relay'. This term will be used throughout this Specification to refer to the subject relay.

The Frequency 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

- any front contact is closed when the specified conditions required to energise the relay are not or have not been met since the relay was last energised
- 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.

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 returned for overhaul or repair in an 'as found' condition after being removed from its working position on the railway.

A general view of a Frequency Relay is shown in Figure A.

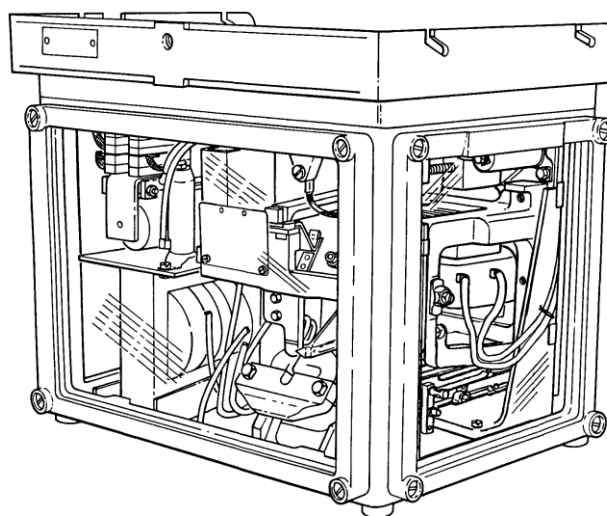


Figure A. General view of a Frequency Relay

The service life of this equipment is 10 years. The shelf life is 3 years.

6. Usage of item

A Frequency Relay is used in conjunction with other items of equipment to make a spot measurement of a train's speed at a specific point on the track. If the speed of a train is known to be lower than a set speed, then it would, in the right circumstances, be safe to clear the next stop signal and allow the train to safely advance into the next section of track. The Frequency Relay measures the frequency of a sequence of 8 pulses generated by the leading positive traction shoe as it passes over the pick-up device which feeds the Frequency Relay.

The pick-up device which generates the input signal consists of 16 series connected coils wound around permanently magnetised cores spaced approximately 6" apart and set in an 8 foot long section of the positive traction rail. The cast iron positive pick-up shoe of the train interacts with the magnetic flux of the succeeding cores and generates a rudimentary sinusoidal signal consisting of eight cycles of A.C. voltage at a frequency dependent on the speed of passing of the shoe, and hence the train. This device is referred to as the Train Speed Inductor. This Specification does not cover any aspects of the Train Speed Inductor.

The output of the Train Speed Inductor is fed to a thermionic valve amplifier which amplifies the power sufficiently for the output of the amplifier to energise the Frequency Relay providing that the frequency is within the acceptable limits. This Specification does not cover any aspects of the Train Speed Amplifier and Power Supply.

The Frequency Relay has an upper and a lower cut-off point in its response curve. Therefore only trains detected to be within a specific speed window will operate the relay. Whilst it may be safe to allow a train going less than the detection speed to pass unchecked, the Frequency Relay will fail to operate for 'below speed' trains and other signalling techniques are employed to handle these conditions.

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

Three variants of the Frequency Relay are covered by this Specification, each with its own speed range. Speed ranges of 10 – 25 MPH, 10 – 20 MPH and 15 – 30 MPH are covered. All relays operate on both 33¹/₃ Hz and 125 Hz supplies. The Frequency Relay has its own unique colour scheme for the case and window frames and each variant uses a unique slotted top frame to prevent interchange of relays with different speed settings.

7. Equipment design outline

Key design features of all Frequency 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 the vane spindle
- A combination of contact materials, pure carbon and silver, that are non-weldable, for use as front contacts
- An operating mechanism that only responds to AC energisation within a range which represents the speed detection window of the relay

Two separate relays are contained within the relay housing, an A.C. frequency, or speed, detecting relay made frequency sensitive by virtue of a parallel tuned circuit connected in series with the local winding and a D.C. force guided contacts relay. The speed detector relay consists of an A.C. double element vane relay, type V.T.1 fitted with permanent magnet damping of the vane. The local winding of this relay is tuned with a transformer and capacitor so that the make contacts will be closed only when the windings receive A.C. whose frequency does not exceed that corresponding to the train speed to be detected. A.C. of a higher frequency will produce negative torque on the vane which will prevent it from energising. The D.C. force guided contacts relay contained within the relay case is fed through a rectifier/capacitor unit from a 100V A.C. local supply. Each relay has 3F/3B independent contacts, two of which are being used. Contacts are wired to provide 1F/2B contacts on the terminal top. When the A.C. vane front contacts are made, the D.C. relay is energised and sticks up over its own contact until released by the control circuit. It is, therefore, necessary for the signal circuits to prove both relays down through their back contacts in series before the relay is called on to be active again.

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. 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. Scope

This specification applies to the following relay variants.

Item	Stores List No.
Train Speed Detector Relay, style LT, 10 – 25 MPH	55-S-137
Train Speed Detector Relay, style LT, 10 – 20 MPH	55-S-138
Train Speed Detector Relay, style LT, 15 – 30 MPH	55-S-139

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

9. Critical functions

Critical Functions of the Frequency Relay are defined to be:

Fail-safe Operation: The equipment is designed and manufactured with the underlying premise that the speed sensing elements of the relay will only energise when a signal falling within the acceptable pass band of the relay is applied to the relay input terminals. The speed sensing vane is mounted in jewelled bearings and is built to the same exacting standards as other signalling safety relays.

High Integrity Electrical Insulation: All parts of 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.

Non-weldability of contacts: The contact materials used in the critical parts of the relay 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.

Electrical Safety. Satisfactory earthing and bonding of the Train Speed Detection 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	Service critical – sole dependence Occurrence of this deviation alone may lead

Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
	the probability of an event which may lead to an incident causing death or injury.	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

10.1 Train speed detection performance

No formally stated train speed detection parameters are recorded for this equipment. Testing to meet practical requirements is carried out using a mechanical frequency generator and an amplifier and power supply as used in service conditions. Performance figures are reflected in the tests specified in the Electrical Tests section of this Specification (see section 13.1.6)

10.2 Contact Resistance

The contact resistance of pairs of silver-to-silver contacts shall be $\leq 0.05\Omega$ measured when carrying a current of between 0.1 and 1A (AC or DC).

The contact resistance of pairs of silver-to-carbon contacts shall be $\leq 0.5\Omega$ measured when carrying a current of between 0.1 and 1A (AC or DC).

10.3 Insulation Resistance

The insulation resistance between all parts of the electrical circuits and the case of the relay shall be at least 5 MΩ when measured at 1000V DC.

The insulation resistance between any parts of insulated circuits shall be at least 5 MΩ when measured at 1000V DC.

11. Equipment configuration

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

A convention of using the figure number followed by the item number has been adopted in this document to uniquely refer to specific components where necessary. Thus, item 1-7 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 Frequency Relay are sensitive to the ingress of airborne dust and other contaminants, particularly into the 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 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 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.

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. Although items listed below are not required to be gauged, any excessive or unusual wear shall be watched for and treated as described in section 13.1.3. Examples of unusual wear on these items include Contact Braids which have started to disintegrate, Headed Pins worn to ,say, less than 80% of regular size and Internal Wiring which has insulation which is showing physical deterioration (other than a colour change).

Top Gasket	Window Gaskets (all)	PVC Glass Seals (all)
Internal wiring	Locking Plates (all)	Tab Washer (2-3)
Contact Braids (all)	Earth Braid Assembly	Headed Pin (2-22)
Internal Wiring - all	Spade Terminals (1-28)	Rectifier
Carbon Contact Spring (3-21)	Spring Contact (carbon) (6-6)	Split Pin (6-21a)

The items listed below shall be discarded and replaced with equivalent items as specified in the Illustrated Parts List.

Capacitors not to current design ► see warning below ◀	Aluminium Top Frames	
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WARNING: Although no oil-filled capacitors using P.C.B.'s (Poly-Chlorinated Biphenyl) have knowingly been used in Frequency Relays, the handling and disposal of these discarded components should be treated as though they do contain a P.C.B. based oil.

The Local Coils and Control Coils shall not be removed from their respective iron systems 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 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 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 Support Castings for the Vane Relay section (items 2-23, 2-24, 2-25 and 2-26) and their associated fixings and locking devices shall be removed as a complete unit and not dismantled until the results of the examination show that further dismantling is necessary.

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, 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.

The Support Castings for the Vane Relay section (items 2-23, 2-24, 2-25 and 2-26) shall have a bright finish. All traces of previously used paint finishes shall be removed. Particular attention shall be paid to the preservation of thread forms.

All previously used paint finishes shall be cleaned off the Local Iron System Assembly and the Control Iron System Assembly (items 4-1 and 4-17) using a wire brush or other similar tool without dismantling the assemblies.

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 side frames shall be cleaned and dried to remove any residue.

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. All instances of electrical arcing or tracking affecting insulating components shall be treated as unusual 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 Top Plate (Item 1-9)

The Top Plate shall not exhibit any signs of cracks and other damage.

The Top Plate shall not exhibit any signs of tracking or arcing.

13.1.3.2 Relay Case (Item 1-7)

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

Tapped holes shall be checked for damage to threads. Damaged threads are not acceptable.

The blanking discs, (eyelet with disc, item 1-40) shall be checked for tightness and soundness. Loose or damaged items shall be replaced with new.

13.1.3.3 Capacitor C1 (Item 1-33)

The capacity shall be measured and confirmed to be within the range $6\mu\text{F} \pm 2\%$. [CPS01]

13.1.3.4 Jewelled bearing assembly (Item 2-1)

The external surfaces of housing shall not exhibit any signs of wear or damage. Thread form shall not exhibit any signs of cracking or over tightening.

The diameter of the barrel jewel shall be gauged to be within the limits of 0.0950" to 0.0970". [CPS02]

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. [CPS03]

13.1.3.5 Vane and spindle assembly (Item 2-4)

All component parts of the assembly shall be securely fastened together. All riveted joints shall be checked for tightness.

The Vane shall not exhibit any signs of cracking.

The Pivots shall be firmly fixed in the ends of the Vane Spindle. They shall be tested for diameter and true running with respect to the shaft diameter. Each pivot shall have a diameter of not less than 0.0910" when measured in three orientations at approximately 120° apart. The eccentricity of each pin when measured in relation to the end of the shaft shall be no greater than 0.001" TIR (Total Indicated Reading). [CPS04]

Failure of either pivot to meet both parameters 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. [CPS05]

The Link Pin hole in the Spindle Link Arm (item 2-15) shall be examined and gauged to be within the range 0.099" – 0.101". [CPS06]

The slot for the Vane Link shall not possess burrs. The slot width shall be gauged for a minimum width of 0.073" [CPS07]

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 Vane link (Item 2-21)

The maximum acceptable diameter of the pin holes in the vane Link is 0.101". [CPS08]

13.1.3.7 Support castings assembly (items 2-23, 2-24, 2-25 and 2-26)

The castings shall not show any evidence of previously used paint finishes. **All** traces of paint shall have been removed.

The assembly shall be securely fastened together with no detectable movement between the sections. Loose joints shall be tightened and new locking components fitted as necessary.

The assembly shall not exhibit any signs of cracking or corrosion.

13.1.3.8 Roller (Item 2-40)

The surface of the Roller shall not be broken or otherwise damaged. The spindle shall be firmly pressed into or embedded in the rubber moulding.

13.1.3.9 Local iron system (Item 2-53) and Control iron system (Item 2-54)

The assembly shall be tightly held together. All securing bolts shall be tight, with their locking plates folded closely into position to secure the fixings. The coil shall not be free to move over the lamination stack. Coils that are loose may be packed with SRBF shims to secure them providing that the coil outer covering has not been chaffed. The coil connection tags shall be securely attached to the coil. Coils with chaffed outer insulation or loose coil tags shall be replaced with new items.

The pole faces of the stack shall be at right angles to the bolting-down face to within 0.001" measured across the thickness of the stack. Assemblies not meeting this criteria shall be re-aligned after slackening off the fixings. New Locking plates shall be fitted if re-aligning is necessary.

The insulation resistance between the coil terminals and the iron core shall be measured. It shall be as specified in section 10.3 of this Specification.

13.1.3.10 Resistors (Items 2-64a/b and 2-65)

Each resistor shall be examined for physical damage – vitreous coating shall be complete and the unit shall be securely attached to its fixing foot.

The resistance of each unit shall be measured. The resistance shall be as given below.

Resistor Ref.	Nominal Value	Minimum acceptable	Maximum acceptable
R1	60 Ω	56 Ω	64 Ω
R1	90 Ω	85 Ω	95 Ω
R2	100 Ω	94 Ω	106 Ω

13.1.3.11 Operating Arm Assembly (Item 3-1)

No components of the Assembly shall exhibit any evidence of cracking, tracking or arcing.

The minimum acceptable diameter of the central portion of the Operating Arm Rod (item 3-2) is 0.092".
[CPS09]

The Indicator Arm (item 3-11) and Indicator (item 3-12) shall be firmly attached to the Spindle Carrier (item 3-10).

13.1.3.12 Contact Assembly – VR Relay (Item 3-15)

The Assembly shall be securely riveted together. The feed-through conductors shall be firmly embedded in their mouldings which shall be complete and show no signs of cracking.

The silver contact section of the Contact Springs (items 3-20 and 3-22) may be refurbished if only light pitting is present. (See section 13.1.4.4)

13.1.3.13 Matching Transformer (Item 5-1)

The transformer shall not show any signs of overheating or insulation breakdown. All terminal connections shall be securely attached to the bobbin.

The insulation resistance between the winding and the core shall be as specified in section 10.3 of this Specification.

13.1.3.14 Capacitor C2 (Item 5-5)

The capacity shall be measured and confirmed to be within the range $2\mu\text{F} \pm 2\%$. [CPS10]

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)

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

13.1.4.1.2 Case (Item 1-7)

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 coded 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 1-2 and 1-2a)

The 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 Support Castings Assembly (items 2-23, 2-24, 2-25 and 2-26)

The Support Castings Assembly 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.

13.1.4.3 Vane and Spindle Assembly (Item 2-4)

Worn pivots (items 2-20) shall be replaced in pairs.

13.1.4.4 Contact Spring (silver) (Items 3-20 and 3-22)

Tips with a flattened surface which cannot be restored to a cylindrical form (except item 3-20 which is designed to have a flat contact surface) by light dressing 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 finished 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.

13.1.5 Assembly Criteria

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

Final adjustments and settings, some of which are common to all variants and others which 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 60]

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 1-8) shall be cleared of paint to provide a bright metal surface to ensure good electrical continuity between the Top Frame (item 1-8a/b/c) and its fixing screws (items 1-11).

13.1.5.1 D.C. Relay

The Original style 'W' relays were unsatisfactory because of fracture of the flexible armature connection resulting from its excessive movement.

This Relay was redesigned to Drawing No B.13484/1 and restyled 'WLT' to overcome this defect. Both types have now been replaced by a high reliability sealed unit. If a relay being overhauled contains a 'W' or 'WLT' style relay, it should be replaced with a force guided contacts relay and existing resistor R3 (2000 Ω) removed.

The maximum pick-up voltage shall be 83 volts D.C. The minimum release voltage shall be 11 volts D.C. [CPS18]

13.1.5.2 A.C. vane relay type V.T.1

The air-gap formed by the Local Iron System (item 2-53) and the Control Iron System (item 2-54) shall be 0.078" – 0.085". The air-gap shall be aligned so as to allow a vane gauge 0.076" – nil +0.001" in thickness to swing through the gap without touching either iron system at any point during its swing. [CPS29]

The Damping Magnet (item 2-27) shall be positioned so that the air-gap between the pole faces is parallel with the plane of the vane (item 2-5) and aligned so that the vane gauge used to check the alignment of the Iron Systems (see previous paragraph) also swings between the pole faces of the magnet without touching any part of it. [CPS30]

The air-gap between the pole faces of the Damping Magnet (item 2-27) shall be free of all foreign material, particularly magnetic swarf, etc.. [CPS31]

The Jewelled Bearing Assemblies (items 2-1) shall be adjusted and locked in position to allow The Vane and Spindle Assembly to have an end float of 0.010" – 0.015". The minimum air-gap on either side of the vane for any position of the Spindle shall be 0.010". [CPS32]

The Operating Arm Assembly (item 3-1) shall fit into the spindle grips on the end of the Silver Contact Spring Assemblies (items 3-22) and shall resist a force of 20 oz. applied in a direction to pull it free. [CPS33]

The return effect on the Vane and Spindle Assembly (item 2-4) shall be measured with the Stud (item 2-16) in a horizontal position before fitting the Link (item 2-21). The return effect shall be 30 – 33 gm.cm.. [CPS34]

Note:- Any adjustment required to be made to the contacts shall be made by setting the Terminal Strips which form part of the Contact Insulator Block (item 3-18).

The Contacts shall be aligned to have full overlap with mating faces parallel to each other to give a full line contact across the whole width of each contact pair.

The difference between the point of making of each pair of contacts shall not exceed 0.005". [CPS35]

The gap between open front contacts shall be 0.060" – 0.070" with the relay in the fully de-energised position. [CPS36]

The gap between back contacts shall be 0.030" – 0.040" when the front contacts are just made. [CPS37]

The contact pressure of each front contact and each back contact shall be 50 – 60 grams with the relay in the fully energised or de-energised condition, as appropriate. [CPS38]

A thin horizontal black line shall be painted on the front section of the Support Casting (item 2-25) opposite the Indicator (item 3-12) at a point to indicate where the front contacts just close. A second line shall be painted to indicate the position of the Indicator when the contact pressure reaches 22 grams.

The operating characteristics of the basic relay shall be verified by testing it when wired in accordance with Figure B. Tests shall be conducted as described in Table A.

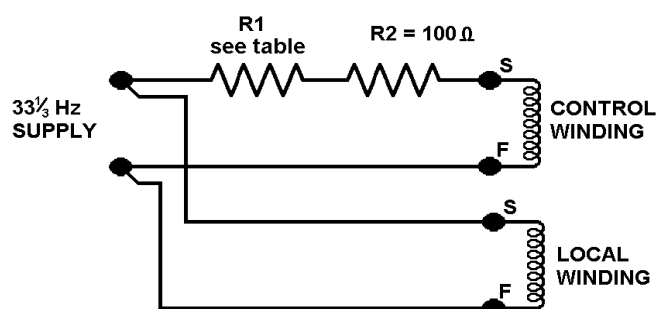


Figure B. Basic relay test circuit

TEST	Conditions	R1 =60Ω	R1=90 Ω	
Phase test	Relay moves towards energised position	≤ 25.0 volts		See note below