



**INSTITUTION OF RAILWAY SIGNAL ENGINEERS
MINOR RAILWAYS SECTION**

GUIDELINE ON

**MANAGEMENT OF
SIGNALLING RELAYS**

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TABLE OF CONTENTS

1.	INTRODUCTION	4
2	DEFINITIONS	4
3	SAFETY VERIFICATION	4
4	SIGNALLING RELAYS	5
4.1	TYPES OF RELAY	6
5	MAINTENANCE	7
5.1	OVERHAUL AND REPAIR.....	7
5.2	STORAGE.....	8
5.3	PLACING INTO SERVICE	8
5.4	INSPECTION	8
5.5	RELAY TEST SETS.....	9
5.6	PERIODIC REPLACEMENT/OVERHAUL.....	9
5.7	RETURN TO SERVICE.....	10
5.8	RECORDS AND MONITORING.....	11
5.9	SILVER MIGRATION	11
6	REFERENCES	12

1. INTRODUCTION

This guideline gives advice on the care and management of relays used for safety critical and safety related applications in railway signalling systems, to ensure that they perform safely and reliably throughout their expected life. It is written from the perspective of UK practice.

The IRSE Minor Railways Section has used its best endeavours to ensure that the contents of this document are factually and technically correct and that it is suitable for its stated purpose but the IRSE Minor Railways Section cannot be liable for any subsequent use to which the document may be put.

Railway signalling systems are fundamental to the safe operation of railways and must perform predictably and reliably. Part of the design philosophy of signalling systems is that the relays in such a system will operate with a very high level of integrity and if they ever fail, will fail to a safe state.

In consequence signalling relays are high quality, precision, pieces of equipment manufactured to close tolerances, which should be handled, transported and stored with care. If correctly cared for they should give very many years of reliable service.

This Guideline deals with the selection, care and use of those precision signalling relays designed for use in safety applications.

There are other applications associated with signalling systems which do not affect safety and for which simpler, and hence cheaper, relays may be used but these fall outside the scope of this document.

2 DEFINITIONS

Front contact	A contact closed when the relay is energised
Back contact	A contact closed when the relay is de-energised
Line relay	Any relay used for the control of one circuit by another over a line or wire.
Relay plugboard	The fixed mounting for a plug-in relay into which the circuit wiring is connected.

See also IRSE Guideline document "Glossary of terms for Signalling and Telecommunications".

3 SAFETY VERIFICATION

All the readily available UK signalling relays were designed for, and have been used in, railway signalling systems over many years. Therefore, provided that they are used within their design parameters, they may be employed in safety signalling applications without any further safety verification.

If however it is intended to use non signalling relays in a safety application it will be necessary to carry out a formal Safety Verification, as required by the current legislation, to demonstrate that any risks introduced by the use these relays can be and will be safely managed.

Safety Verification may also be required if it is intended to introduce relays from Continental Europe, which display some significant design differences from UK practice.

4 SIGNALLING RELAYS

A relay is an electrically operated switch. Most relays are of the tractive armature, type, having an internal electromagnet which, when it is energised by an electric current, creates a magnetic field which attracts an armature towards it.

Mechanically connected to the armature are a number of internal contact arms which move with the armature and make contact with fixed internal contacts at one or both ends of their travel.

External terminals allow current to be fed to the relay coil and allow circuits to be connected to each of the relay contacts.

When the relay is energised the armature moves, causing those contacts which are normally closed when the relay is de-energised to open, and causing other contacts to close.

Contacts closed when the relay is energised are known as 'front' contacts; and contacts closed when the relay is de-energised are known as 'back' contacts.

Energised and de-energised states are frequently referred to as 'picked' or 'dropped'; or 'Up' and 'Down' respectively.

Most signalling relays are designed to be operated by direct current (DC). The most common operating voltages are: 12v, 24v and 50v; but relays can be found which operate at other voltages.

Some relays are designed to be operated by alternating current (AC) and are usually found on or close to lines using DC traction where stray traction currents could interfere with the correct operation of DC signalling circuits. AC relays are normally of the induction type where a pivoted vane is caused to move between the poles of an electromagnet by magnetic fluxes induced in it.

Induction vane relays are of two types: single element relays which have only one coil; and double element relays which have two coils and require a feed from two independent AC supplies. One, usually called the local supply, providing the majority of the power; and the other, called the control supply, only needing to provide a small amount of power. Single element relays are usually only used for line circuits; while double element relays are used, for instance, for track relays and point detection.

Signalling relays differ from most other types of electromagnetic relays, e.g. 'Post Office' type telecoms relays, in that the contacts are held within a insulated comb to ensure that a 'back' contact cannot make when the relay de-energises if any of the 'front' contacts have remained closed due to welding or other cause, or vice versa.

Signalling relays used in the UK usually have one contact of each pair formed of a silver/carbon compound and the other of metallic silver to minimise the risk of the contacts welding together.

Signalling relays usually have a number of contacts; and different relays, even of the same basic specification can have a number of different combinations of contacts. For example spec BR930 50v relays may be found with 8 front and 8

back contacts or with 12 front and 4 back contacts; and with other variations of these where not all the contacts are provided.

Most modern relays plug into a base to which is connected the fixed circuit wiring, thus enabling the relay to be changed without disturbing the wiring. A set of coding pins ensure that a relay cannot be inadvertently replaced by a relay with a conflicting contact configuration or different voltage.

Plugboards are usually obtained with the coding already applied but it is possible to obtain blank plugboards which require to be drilled to apply the coding, in which case great care should be exercised to ensure that this is done correctly.

All signalling relays should be clearly labelled to identify the type of relay and its serial number.

In all cases when designing any signalling system care should be taken to select the appropriate type of relay for each application; and within that type the most appropriate operating voltage and contact arrangement should be selected from those available.

4.1 TYPES OF RELAY

AC immune relay	A DC relay which is not influenced by any stray AC current in the coil circuit.
Biased relay	A DC relay which will only operate with a supply of the specified polarity. (Sometimes known as a two-position polar relay)
Contactor relay	A relay with some heavy duty contacts for controlling high current equipment such as point machines.
Double wound relay	A relay with two coils, either of which will operate the armature.
Lamp proving relay	A relay designed to be connected in series with a signal lamp and operating with a particular value of current flowing, thus detecting that the lamp is alight. Lamp proving relays may be designed to operate with AC, or DC, or both.
Latched relay	A relay which once energised will remain in the operated state until it is intentionally unlatched, usually by energising a separate 'un-latching' coil winding.
Module	A unit which has the appearance of a relay, but may not necessarily be one, or it may be a non-safety critical type. Examples include: Earth leakage detectors, low voltage alarms, flasher units, capacitor resistor networks, first filament changeover relays and alarms, panel indication relays, etc.; this list is not exhaustive. The module may contain relays of a non safety critical type such as PO3000 type or Varley
Motor relay	A time relay where a motor operates contacts through a train of gears
Neutral relay	A simple relay as described above which will operate when a direct current of either polarity passes through the coil.
Plug-in relay	A relay designed to be mounted on, and connect into, a plugboard thus enabling the relay to be replaced without disturbing the circuit wiring. Both relay and plugboard are coded to ensure that a relay cannot be replaced by one of a different type or configuration. The most common types of plug-in relay are the BR 930 (Q) Series, made by a number of manufacturers, the relays from different manufacturers being interchangeable; and the rather older B and P series relays manufactured by Westinghouse.
Pneumatic relay	A time relay where the time delay is determined by air leaking from a bellows through a small aperture.

Polar relay	A relay which will operate to one of two states depending on the supply polarity and release to a third state. (Sometimes known as a three-position polar relay)
Shelf Type relay	A free standing relay with the circuit wiring directly connected to terminals on the relay (Note Some relays of this type do have the terminals on a detachable top, enabling the relay to be replaced without disturbing the wiring, in a similar manner to a plug-in relay)
Slow Pick Up relay	A relay which does not operate immediately when the coil is energised. This generally is in the region of 250mS. If the time delay is greater than one second the relay is usually referred to as a time relay.
Slow Release relay	A relay where the armature does not move immediately when the energising current is turned off. This is generally between 250mS and 400mS and normally covers the changeover time of neutral relay. Certain relays can have an extended time up to a second. If the time delay is greater than one second the relay is usually referred to as a time relay.
Thermal relay	A time relay where the timing element consists of a bi-metallic strip which is heated when the relay is energised.
Time relay	A relay containing a timing mechanism which operates the contacts a set time interval after the coil is energised or de-energised dependant on application. In some relays it is possible to vary the time interval. This can be achieved by the use of the methods below, by a simple capacitor network or by more complex electronics
Track relay	A relay designed for the specific purpose of forming part of a track circuit. Track circuit relays are particularly critical since any change in the relays operating characteristics can radically alter the characteristics of the track circuit and any failure is likely not to be protected by any other part of the signalling system.
Two element relay	An AC Vane relay where most of the power to operate the vane is supplied from a local supply, allowing the vane to operate when only a small amount of power is applied to the control input.
Vane relay	An AC relay operated by an inductive vane mechanism.

5 MAINTENANCE

5.1 OVERHAUL AND REPAIR

Because most signalling relays are safety critical components of a safety system, most work to repair or overhaul these relays is itself safety critical work. The precise operating characteristics and close tolerances of signalling relays mean that this is a specialist activity which can only be carried out safely by people who are fully competent and have the necessary tools and equipment.

In practice the overhaul and repair should only be carried out in a properly equipped and staffed servicing facility, such as a relay manufacturer or other repair centre.

Signalling relays are contained within sealed covers and the cover should only be removed in a service centre. If a relay is found to have a broken seal it should not be used until it has been examined at a service centre.

When a relay is repaired or serviced the information on the original label, particularly that relating to manufacturer and date of manufacture should be preserved.

5.2 STORAGE

Signalling relays should be stored in a dry, well ventilated, place where they are not subjected to extremes of temperature.

5.3 PLACING INTO SERVICE

It is recognised that many Minor Railways will extensively make use of second-hand equipment. A relay which may appear in good condition may in fact have been dropped, or roughly handled. Some parts such as the jewelled bearings of vane relays cannot be inspected, and may have been damaged during recovery. Where relays are recovered, records should be kept of their source. It is recommended that second-hand relays are functionally tested before re-use, and if there is any doubt whatsoever as to their operation or condition, they are sent for servicing at an approved service centre.

Before being placed into service the relay should be checked to ensure that it is of the correct type, operating voltage and contact arrangement (this check should still be made with plug-in relays since, even though the pin coding of the relay plugboard *should* prevent a relay being fitted which is unsafe in that position, it may allow a relay to be fitted which does not have all the necessary contacts; or coil windings).

The physical condition of the relay should also be checked for any sign of damage, internal or external, any distortion of transparent cover, and any sign of corrosion or moisture inside the relay. In case of doubt the relay should be rejected and sent for servicing before it is used.

The records of relays in service should be updated.

A label should be fixed to the relay rack beside the relay showing the relay's circuit function, to enable it to be quickly identified when inspecting or testing.

All the wires connected to the relay or relay plugboard should also be labelled so that if it is necessary to disconnect any wires they can readily be replaced in the correct place. The wires connected to relay plugboards are normally identified by fitting them with beads showing the contact number, e.g. A2, B4, etc.

As far as practicable relay rooms and apparatus cases should be heated to avoid extremely low temperatures which can lead to condensation within the relay. Excessively hot temperatures should be avoided as this can lead to drying out of the cables and wiring leading to wire degradation.

5.4 INSPECTION

Relays should be inspected periodically for any signs of damage, distortion, corrosion, condensation or ingress of moisture, dirt, insects, etc. (Note: A slight misting on the inside of relay covers is not uncommon and does not appear to be detrimental.)

Any opportunity should also be taken, e.g. track circuit testing, to observe the operation of the relay which should be a crisp positive movement. If the relay is sluggish in operation this is indicative of a problem (unless the relay is designed to be slow to operate or release).

If any damage, deterioration, or sluggish operation is observed the relay should be replaced and sent to a service centre.

5.5 RELAY TEST SETS

A useful aid to inspection and testing is a relay test set into which a relay can be plugged and then operated to check the 'operate' and 'release' voltages and currents, the resistance of each pair of contacts, and other parameters such as the immunity of biased relays to reverse polarity voltages.

Test sets can also be designed to measure the time of operation of time relays, and to perform a limited amount of contact cleaning.

Such test sets can be obtained commercially, but they can also be constructed fairly easily from readily available components; provided that they are then adequately calibrated before use.

Ideally a copy of the specification for the type of relay concerned should be available and the relay should be tested against the specified parameters.

Commercially available relay tests sets can be obtained from Unipart Rail, Invensys, Mors Smitt and MRD Rail Technologies Pty, Australia. Typical costs are between are between £5,000 and £20,000.

5.6 PERIODIC REPLACEMENT/OVERHAUL

At some point in time all relays will reach the end of their reliable service life and will need to be removed from service and overhauled before they are put back into service.

The service life of each type of relay is a balance between the cost of replacement and the risk of causing failures during the changing process set against the risks of failure in service.

Certain types of relay are recognised to have a finite reliable service life, either because of the particularly safety critical applications in which they are used, or because elements of their construction or mechanism are liable to change or deteriorate over time.

These include:

Timer relays (e.g. BR937, BR962, BR946, BR947, AEI-GS AS)

Magnetically latched or magnetic stick relays (e.g. BR935, BR936)

Biased or polar relays (e.g. BR932, BR961, Tyers G1, Shelf Type)

Track relays (e.g. BR938, BR939, BR966 AppF2, BR968, VT1, Shelf Type)

Vane relays

Searchlight signal mechanisms

The period at which these relays should be replaced and overhauled depends on a number of factors including: the nature and construction of the relay, the safety criticality of the application, and the frequency of operation. Typically a BR930 series relay should be able to operate between 100,000 and 1,000,000 times in its life time and application.

For example: timer relays often contain components which can deteriorate over time changing the time value of the relay; magnetic latched/stick relays and biased relays contain additional permanent magnets which can weaken over time; any change in the characteristics of a track circuit relay can affect the ability of the track circuit to detect trains; and any failure of a searchlight mechanism is liable to result in a wrong signal aspect being displayed.

A period of ten years is commonly used on mainline railways for relays in these categories, with discretion to extend the replacement period where the frequency of operation is low or the nature of the application justifies it. Ten years is a very conservative figure based on fairly high frequencies of operation. For Minor Railways a much longer replacement period may be appropriate for most types of relay; provided that the relays are periodically inspected, and seen to function correctly, and display no signs of deterioration.

Biased relays need to take into consideration the time that they spend connected with a reverse polarity directly across the coil, as in the long term this will weaken the permanent magnet that gives the biased characteristics.

Polar relays need to be assessed as they spend a lot of time energised in one position as the coil may become saturated and remain in the same position when the supply is disconnected.

Other relays, particularly DC neutral relays, are less prone to deterioration and in most cases the best course of action in terms of cost and reliability is to leave the relay in service, subject to periodic inspection, until it displays signs of deterioration.

The policy for replacement and the replacement period adopted for each type of relay should be clearly recorded.

If a test set is available and a relay, when due for overhaul, is tested and found to operate within all its specified parameters and is seen to operate crisply, it may be considered for a further period of service before overhaul. The policy on returning relays to service after such tests without overhaul should be recorded.

From time to time the manufacturers may find faults or issues with a particular class of relay. They devise a modification, (such as a revised pivot plate) which addresses this issue, and therefore the periodic servicing regime at an authorised service agent will ensure that the relay is modified to the new modification status in a timely and correct manner.

Some equipment in particular uses very old relays, for example tablet and key token machines; some of these relays are now around 100 years old. It is essential that relays such as these are regularly serviced and inspected to achieve assurance of their continued fitness for purpose, and upgraded or replaced if need be. Tyer's no'6 tablet machines are in particular subject to degradation of the soft iron horseshoe magnets.

5.7 RETURN TO SERVICE

In general once a relay is removed from service it should not be re-used until it has been overhauled at a service centre. When a relay is taken out of use well before the end of its expected service life, e.g. during alterations, it may be re-used provided that it shows no signs of deterioration; but a note should be made on the records of the period that the relay had spent in service in its original application so that its total time in service is taken into account for replacement purposes.

5.8 RECORDS AND MONITORING

Records should be kept of all relays showing the Serial Number, date placed in service and the function the relay is allocated to.

A record should be kept of the replacement period it has been decided to adopt for each type of relay; together with the assumptions and any risk assessment leading to that decision.

All failures should be recorded by equipment type and failure mechanism in order that the reliability of each type of relay can be monitored and changes made, if necessary, to the replacement period.

5.9 SILVER MIGRATION

A particular problem encountered with some relays is silver migration – the movement of metallic silver ions onto and through insulation materials. Initially it is restricted to the surface, but with time penetrates into the structure of the material. It can conduct electricity and is able to bypass contacts in circuitry and introduce connections between different circuits. It can be observed as a silvery deposit on the surface of the insulation and once present is almost impossible to remove.

For silver migration to take place the following simultaneous conditions are needed:

- silver or silver plated conductors,
- moisture, and
- a potential difference across the insulation.

Insulating material which will absorb moisture (such as phenolic compound) will accelerate the process but is not a pre-requisite.

As originally manufactured BR930 Series and Westinghouse B and P Series relays used black phenolic plugboards; and Westinghouse P series relays also had black phenolic bases and used black phenolic insulation inside the relay.

Subsequently the black phenolic bases and relay insulation have been largely replaced by blue epoxy and most recently by cream/white or grey insulation material.

Where BR930 or Westinghouse B and P Series relays are still using black plugboards, or B and P Series relays have black bases or internal insulation, they should be carefully examined for any sign of silver migration and if any is found the plugboard and/or relay should be changed for replacements to the latest standards.

Since moisture is a pre-requisite for silver migration it is likely to be found more frequently in apparatus cases than in heated relay rooms.

In recent years the 'spade' connectors, used for connecting circuits into the plugboards, have been changed from silver plated to tin plated. Tin plated connectors are not prone to silver migration and can safely be used with the older black plugboards, provided that those plugboards do not show any evidence of silver migration from previous use.

6 REFERENCES

GK/RT0107, Issue 1, Silver Migration

GK/RT0129, Issue 1, Life Management of Signalling Relays

GS/IH 2C05, Issue 2, Installation Handbook – Relays: Basic Principles

The Railway and Other Guided Transport Systems (Safety) Regulations 2006

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