



(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 detail the test requirements for factory acceptance of the QSEV relays before use.

2. References

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

3. Abbreviations and symbols

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

AC	Alternating current;
DC	Direct Current;
CPS	Critical Parameter or Setting;
CR	Criticality rating;
DCN	Design change notice;
Hz	Hertz;
in.	Inch;
LED	Light-emitting diode;
LU	London Underground;
MR	Metronet Rail;
MΩ	Megohm ($1 \text{ M}\Omega = 1 \times 10^6 \Omega$);
OEM	Original equipment manufacturer;
Ω	Ohm;



QNHX1 Westinghouse miniature AC line relay to BR specification BR 966;

rms Root-mean-square;

SEV Single-element vane;

SSL Sub-Surface Lines;

V Volts.

4. Definitions

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

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;

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;

Infraco – Any of the three companies: LUL Nominee BCV Ltd, LUL Nominee SSL Ltd, or Tube Lines Ltd;

QSEV relay – A compatible replacement for an SEV relay, which is constructed with two integral QNHX1 relays (refer clause 7.2);

The Client – The Client is the Infraco representative for administering the contract under which the manufacture is being performed;

The Contractor – The Contractor refers to the organisation responsible for the delivery of the QSEV relay.

5. Introduction

5.1 This specification has been written to detail the acceptance test and performance requirements of the QSEV signal relay which is used on the signalling system on the London Underground.

5.2 The QSEV 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 its life.

5.3 Any failure condition which causes

- The QSEV relay as a whole or any of the internal components to behave as though in an energised state without the required voltage being present at the energising terminals of the QSEV relay,
- signalling circuits to be misfed
- any front and any back contact to be closed simultaneously, or
- any contact or coil to have an electrically conductive path to any other contact or coil or lamination,

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 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 relays in service. It is the contractor's responsibility to ensure compliance with the provisions of this specification.

5.4 The service life of this equipment is 20-years. The shelf life is 3-years.



6. Usage of item

6.1 The QSEV relay has been designed as a safety critical relay used to directly authorise the movement of trains on the London Underground. QSEV relays may be used in Interlocking Machine Rooms and trackside location cases to authorise train movements through complex and very busy track layouts. It is therefore imperative that the front contacts open when the voltage applied to the pickup terminals is reduced below the drop-away value.

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

The QSEV relay is designed to operate on both $33 \frac{1}{3}$ Hz and 125 Hz, 100 V AC power supplies, and has six front and four back contacts.

7. Equipment design outline

7.1 Key design features of the QSEV relay include:

- Construction that is designed to be, as far as is practicable, fail-safe in operation.
- An operating mechanism that only responds to AC energization.
- Front contact diversity, with both QNHX1 relays contained within the QSEV to be energised for the front contacts to make.

7.2 The relay is designed to perform as a universal, plug compatible, high integrity replacement for the SEV relay. It utilises two QNHX1 relays, produced to meet British Railways specification No. 966 and MR specification S-SG-0893. The coils of each relay, connected in parallel, are energised via an isolating transformer, providing DC immunity. Front contacts from each QNHX1 relay are connected in series, hence requiring both to be energised for the front contact function of the QSEV to make. The back contacts from each QNHX1 relay are connected in parallel, thereby minimising failure of the signalling due to a contact becoming high resistance.

8. Critical functions and parameters

8.1 Critical Functions

Critical functions of the QSEV Relay are defined to be:

Fail Safe Operation

8.1.1 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, the front 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.

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



High Integrity Electrical Insulation and switching properties

8.1.3 All electrical wiring and insulating components are designed to maintain their integrity throughout the life of the equipment. No failure mode is allowed to compromise electrical isolation between any part of the contact arrangement, the energising coil or isolating transformer of the equipment.

Integrity when used outside normal conditions

8.1.4 The relay has been designed not to energise when supplied with DC, but the isolating transformer and its wiring may become overheated and suffer damage.

High Reliability

8.1.5 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 because of failed equipment.

Electrical Safety

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

8.2 Critical Parameters or Settings

8.2.1 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, assembly, testing of and use of the equipment. To ensure that the significance of certain of the detailed requirements is understood and complied with, a number of CPS's have been designated throughout the text.

8.2.2 Attachment 2 to this specification lists all the CPS's, a reference to the section from which the requirement originates and provides a CR of the importance of each CPS item.

8.2.3 Note that while a CPS will generally be identified in the discussion of a particular stage of the testing and construction, some CPS's must be achieved not only at that stage, but also in the completed relay. These are detailed in the attached CPS List.

8.2.4 The CR is based on the severity of the consequence if there is a deviation from the value specified. Numerical values have been assigned to various levels of the 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	Service critical – sole dependence



CR	Safety related criteria	Reliability related criteria
	Occurrence of this deviation increases the probability of an event which may lead to an incident causing death or injury.	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

8.2.5 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 designs of the process or processes that will lead to the parameter being met are the responsibility of the Contractor.

9. Performance parameters

9.1 Pick-up Voltage

The pick-up voltage shall be less than 80 V AC at both $33 \frac{1}{3}$ Hz and 125 Hz. The pick-up voltage is defined as the lowest voltage which, when applied to the input terminals of the relay by increasing from the de-energised state, causes all of the front contacts to close.

9.2 Drop-Away Voltage

The drop-away voltage shall be greater than 30 V AC at both $33 \frac{1}{3}$ Hz and 125 Hz. The drop-away voltage is defined as the highest voltage existing on the input terminals of the relay, after having been gradually reduced from the normal energising voltage of 100 V, which allows all of the front contacts of the QSEV to open, and all of the back contacts of both component QNHX1 relays to close.



9.3 Contact Resistance

The contact resistance shall be such that, at both 33 $\frac{1}{3}$ Hz and 125 Hz, with 0.1 amps AC rms flowing through the contact, the voltage drop across the contact shall be less than 0.08 V rms when measured across the relay top connections (Equivalent to a resistance of less than 0.8 Ω .)

9.4 Insulation Resistance

9.4.1 The insulation resistance between any parts of the electrical circuits and the case of the relay shall be at least 50 M Ω when measured at 1000 V DC.

9.4.2 The insulation resistance between any parts of isolated circuits shall be at least 50 M Ω when measured at 1000 V DC

(Note: "Isolated Circuit" means where no intentional electrical connection exists between two terminals.)

10. General requirements

10.1 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.

Alternative processes or materials shall not be used. The Client shall have the immutable expectation that equipment manufactured to this version of the specification shall be 100 % compliant with the specification herein.

10.2 Calibre of Staff

Any staff involved in the manufacturing and test process shall be competent in the tasks they carry out and the contractor shall demonstrate this in accordance with the requirements of LU Standard 1-203.

10.3 Operator accountability

Process control documentation is required to be completed by identified certified (stamp-holding) operators and inspectors throughout the assembly 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.

11. Assembly and test definition

11.1 Recovery and Overhaul of SEV Components

Components from existing SEV relays which are required in the assembly of the QSEV shall be overhauled according to specification MR-OS-3415.

11.2 Inspection & Test of Q Relay Components Prior to Assembly

The test documentation, as provided by the manufacturer of the QNHX1 relay shall be individually checked for each relay and plugboard used. Relays and plugboards shall be examined for signs of physical damage before assembly into the QSEV.