

Category 1 Standard

S1094

Heavy Duty Metro Type Escalators and Moving Walks

Issue No.: A6

Issue date: January 2016

Review date: January 2021

MAYOR OF LONDON

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1 Purpose

- 1.1 The purpose of this standard is to define the requirements for the provision and safe conditions of use of Heavy Duty Metro type escalators and moving walks, their spatial requirements and environment on the London Underground System. The requirements of LU Heavy Duty Escalators and Moving Walks can be found in LU Standard S1092.

2 Scope

- 2.1 The requirements of this standard apply to the stages of design, manufacture, installation, commissioning, maintenance and safe conditions of use, spatial requirements and environment.
- 2.2 The term escalator also includes moving walk unless otherwise stated.
- 2.3 This standard applies to Heavy Duty Metro type escalator and Moving Walk installations on the LU Network.

Note: This standard does not include sufficient details to be used for the purpose of procuring escalators or moving walks.

3 Requirements

3.1 General

3.1.1 General

- 3.1.1.1 Suppliers shall ensure that the total system requirements of this standard are met.
- 3.1.1.2 There shall be no potential for single point failures to cause injury or death.

3.1.2 Applicable Standards

- 3.1.2.1 Escalators shall comply with this standard in addition to the provisions of BS EN 115: Part 1 & 2. Where there are any conflicts, compliance with this standard shall take precedence except where a breach of the law would arise.
- 3.1.2.2 Escalators shall comply with the Railway Safety Principles and Guidance Part 1 and 2 and the Building Regulations Approved Documents 'B' and 'M'. Where any conflicts arise between the Rail Safety Principles and Guidance, the Building Regulations and this standard, compliance with this standard shall take precedence except where a breach of the law would arise.
- 3.1.2.3 Escalators shall also comply with:
- a) LU Standard S1371 Station Planning;
 - b) BS 8300: Design of buildings and their approaches to meet the needs of disabled people. Code of practice;
 - c) The Fire Precautions (Sub-surface Railway Stations) (England) Regulations;
 - d) Supply of Machinery (Safety) Regulations;
 - e) The EMC Regulations.



3.1.2.4 The escalator shall meet the safety requirements of BS 7801, BS EN 13015, and Safety Assessment Federation (SaFed) – Guidelines for the safe operation of escalators and moving walks.

3.1.2.5 Materials used in the manufacture of the escalator shall comply with LU Standard S1085 Fire Safety Performance of Materials – Stations and Tunnel Infrastructure.

3.1.3 Conditions

The escalator shall operate in the environment encountered on the LU network. Relevant data regarding the conditions on specific installations is to be supplied in the site specification documentation.

3.1.4 Performance

3.1.4.1 The escalator shall be capable of running continuously at the specified running speed for 24 hours per day, 365 days per year. The escalator shall be capable of being reversed. The escalator specification or the Contract shall define performance level (e.g. Availability, MTBF, MTTR etc.) to be achieved throughout the life of the asset.

3.1.4.2 An operational and maintenance regime shall be in place which ensures reversibility.

3.1.4.3 When stationary, the escalator must be available as a stairway except when the machine is required to be barriered or hoarded off for repair or maintenance work.

Note: The note in BS EN 115 – 1 clause 3.1.8 stating 'escalators are machines - even when they are out of operation - and cannot be considered as a fixed stairway' is interpreted to suggest that the escalator will always retain the status of a machine i.e. it can never be considered to be a fixed stairway as opposed to a machine.

3.1.4.4 The vibration levels for travel on the escalator shall be measured and processed in accordance with BS ISO 18738-2.

Note: Of particular importance is the frequency caused by the interaction between the step chain and step chain sprocket. For example, an escalator running at 0.75m/s with a nominal step chain pitch of 133mm will have an approximate frequency of 5.64Hz.

3.1.4.5 At the commissioning stage, the achieved ride quality shall not exceed the values in row A of Table 1. For the remainder of the asset life, the maximum FFT vibration level for each maintained escalator shall not exceed the value in row B of Table 1:

Row	Maximum at frequency equivalent to 0.75m/s in FFT using 8 sec FFT length (mg)	Maximum RMS (mg)	Average RMS (mg)
A	17.5	15.0	12.0
B	20.0	N/A	N/A

Table 1: Achieved ride quality

3.1.5 Design of components

3.1.5.1 The design of components shall include assessment for strength, durability and, where subject to cyclic or dynamic loading, fatigue life to determine the component service life.

3.1.5.2 The above criteria are not enough to ensure adequate system and individual component integrity. Integrity analyses shall give due regard to the following to minimise the risk of failures due to insufficient design:

- a) Properties of materials;
- b) Stress concentrations arising from geometrical features and welding;
- c) Stresses and combinations of stresses arising from all reasonably foreseeable static, dynamic and cyclic loading conditions;
- d) The system and its constituent components shall not fail under any reasonably foreseeable (including faulted) loading conditions.

3.1.5.3 Component service life shall be calculated on the basis of time to wear-out and an infinite fatigue life to BS EN 1993-1-9 for steel and BS EN 1999-1-1 for aluminium components respectively. All reasonably foreseeable conditions shall be considered, including:

- a) Testing (e.g. weight test);
- b) Normal operation (including fluctuating passenger loads);
- c) Exceptional events (e.g. step-comb collisions and 'lock-ups').

Note: Escalators installed on the LU network, have suffered a history of mechanical component failure, owing to a lack of understanding of the usage and dynamics of the assets, compounded by insufficient attention to design and manufacturing detail. It is important that the errors of the past are not replicated in the next generation of LU's escalators.

Assessments, based solely upon peak duty demands, are insufficient to ensure the long-term integrity of the asset. The objective in the design of components should always be to achieve a nominally infinite fatigue life.

Fatigue calculations should be carried out to accepted codes of practice and in particular, for welded steel components to BS EN 1993-1-9 Design of steel structures, Fatigue. Aluminium die cast components should be assessed to BS EN 1999-1-3: Design of aluminium structures. Structures susceptible to fatigue.

The Contractor should agree calculation methodologies and appropriate assessment codes, with the L&E Engineer, before design commences.

- 3.1.5.4 Where the Supplier uses Finite Element Analysis, guidance is given in Attachment 2.
- 3.1.5.5 Welding is not permitted on one-piece aluminium die cast steps after manufacture in the foundry.
- 3.1.5.6 Welding of one-piece aluminium die cast steps, once in service (e.g. because cleats have been damaged) shall only be permitted with the prior agreement of LU.
- 3.1.5.7 Where welding is adopted on rotating components (e.g. drive and idler shafts) and components that are exposed to dynamic loadings, the requirements of Attachment 10 shall apply.
- 3.1.5.8 Ref. clause 3.1.5.7, the process adopted for welds repairs and associated NDT, shall be agreed in detail, by LU, prior to any work being carried out.

3.1.6 Whole life cost

- 3.1.6.1 Escalators shall have a declared design life.
- 3.1.6.2 The design life of the following key components shall be calculated and declared as a minimum: Step / Pallet, Motor, Gearbox, Drive chain, Step / Pallet chain, Drive and Idler Shaft, Sprockets, Brakes, Track system, Controller (Drive system,



PLC/microprocessor, Inverter), Safety devices, Handrail, Balustrade and Truss. Any additional components of which the design life would be critical to the operation of the escalator shall also be calculated and declared to LU.

- 3.1.6.3 With each new installation or unit replacement a Reliability, Availability, Maintainability and Safety Plan (RAMS) shall be provided for a minimum period of 40 years.

Note: A typical RAMS template can be supplied on request for guidance.

- 3.1.6.4 A Whole Life Design Cost Plan shall be provided for each new installation or unit replacement covering a minimum period of 40 years. This plan shall incorporate the data and component lives as determined through calculation, analysis and testing including the step testing described in Attachment 3.

3.1.7 Movement of approved loads / materials

- 3.1.7.1 Licensing arrangements, as described in Attachment 9 and LU Rule Book 9, shall be adhered to, where it is required to move materials on escalators.

3.2 Supporting structure (truss) and enclosure

3.2.1 General

- 3.2.1.1 The requirements for the configuration of escalators are defined in the LU Standard S1371 Station Planning. The building interface requirements are identified in more detail in Attachment 1.
- 3.2.1.2 Attachment 1, figures 1, 2 and 3 are illustrations of three escalators in a shaft. For escalator shafts with configurations other than three escalators, dimensions shall be extrapolated from the dimensions for a shaft with three escalators.
- 3.2.1.3 The truss design shall be such as to avoid the accumulation of detritus to a level that would be a hazard. The infrastructure designer shall ensure that the infrastructure within which the escalator is installed is accessible for cleaning in a safe manner. The cleaning requirement is described in more detail in Attachment 6.
- 3.2.1.4 The lighting on the passenger side of the escalator shall minimize disorientation from the combined effect of lighting frequency, contrast and cleat spacing of step treads. The designer of services above and adjacent to escalators shall identify the means by which the services will be maintained in a safe manner. Refer to Appendix 9 for Movement of materials and static loading of the lifts and escalators.

3.2.2 Angle of inclination

- 3.2.2.1 For escalators the angle of inclination shall not exceed 30 degrees.
- 3.2.2.2 For moving walks the angle of inclination shall be no greater than 5 degrees.

3.2.3 Access to the interior (i.e. Machinery spaces inside the truss)

Access to the interior shall be provided to BS EN 115 -1 clause 5.2.3 and 5.8.2.1 requirements. In addition, facility shall be provided for a 'three point contact' system whilst entering and existing the standing spaces in the upper and lower machinery spaces within the truss through the floor plates.

3.2.4 Inspection covers and floor plates

Refer to clause 3.7.4 and 3.7.5 for more detailed requirements regarding floor plates and floor trays.

3.2.5 Structural design

3.2.5.1 Truss

3.2.5.1.1 The escalator truss shall not be used to provide support for any other station structure which is not related to the escalator installation.

3.2.5.1.2 The escalator truss and its supports shall:

- a) Sustain all loading (static, dynamic and cyclic);
- b) Transfer loads to the supporting civil infrastructure.

3.2.5.1.3 Based on the rated load as required by BS EN 115-1 clause 5.2.5, the maximum calculated or measured deflection shall not exceed 3mm or 1/1500th (whichever is the lesser) of the distance between adjacent supports.

3.2.5.1.4 Factors of safety used in design shall be consistent with limit state principles for operating and test loading conditions. Under all reasonably foreseeable conditions, including for a 'lock-up' loading condition the integrity of the structure is to be maintained and deflection is to be limited to avoid the possibility of entrapment.

3.2.5.1.5 The truss shall not fail (yield, buckle or fatigue) and the service life calculation shall cater for all reasonably foreseeable conditions, including:

- a) start-ups;
- b) fluctuating passenger loads;
- c) fluctuating motor torque;
- d) brake applications (including brake testing);
- e) faulted conditions (e.g. 'lock-ups' and step-to-comb collisions).

3.2.5.1.6 The truss shall allow access to all components for inspection, maintenance and replacement. The design shall be such that all components on an individual machine can be removed and replaced without affecting the service availability of any adjacent escalators.

3.2.5.1.7 The design shall permit the withdrawal of steps in such a way that all regular maintenance activities can be completed during engineering hours.

3.2.5.2 Tracking

3.2.5.2.1 The deflection of the tracks shall not exceed 1mm between any two adjacent track supports under static passenger loading.

3.2.5.2.2 A dropped step ramp shall be provided at both landings, covering the length of two steps, which shall be designed to support the steps and maintain meshing of the steps through the comb, in the event of failure or loss of a step or chain wheel.

3.2.5.2.3 Tracks, support brackets and up-thrusts shall be designed to withstand maintenance staff using these as a foothold. This shall be taken to mean that a load of 1.5kN applied vertically downward at any point shall cause no permanent deflection.

3.2.5.3 In-Service Strain-Gauge Test of Tracking

3.2.5.3.1 The Supplier shall carry out a strain-gauged step test, for each new escalator, of a given type.



Notes: The purpose of this test, which is in addition to BS EN 115-1, is to check the alignment of the escalator tracking.

Poor tracking alignment will affect step life.

3.2.5.3.2 A new step shall be selected for the test.

3.2.5.3.3 The following shall be agreed with LU, prior to the first test of each escalator type:

- a) type and location of strain gauges;
- b) choice of uni-axial, bi-axial or tri-axial gauges, at each of the above locations;
- c) monitoring methodology;
- d) data sampling and filtering frequencies;
- e) a means of accurately associating strains with locations in the tracking system.

3.2.5.3.4 The step shall be installed in the unloaded escalator and run, up and down, for a sufficient length of time, at contract speed, to determine the information required in section 3.2.5.3.5.

3.2.5.3.5 The Supplier shall provide a report of the test, which shall include:

- a) a discussion of the issues in clauses 3.2.5.3.3 and 3.2.5.3.4;
- b) colour photographs, clearly indicating the location and orientation of the strain-gauges;
- c) outputs from each strain gauge;
- d) where there are areas of high stress, indicative of poor tracking installation, an explanation of the reasons, thus indicating the need to re-work the alignment of the escalator.

Note: The test can also be used to estimate the life of the steps, by calculating the cumulative fatigue damage, in accordance with, for example, BS EN 1999-1-3: However, it is preferable for the maximum level of stress, in the casting, to be less than the fatigue initiating stress level. In carrying out the calculations, the fatigue life shall be assessed against the lowest class of porosity which might arise from the manufacturing process.

3.2.5.4 Truss assessment of existing trusses when reused

3.2.5.4.1 The structural integrity assessment for re-use of existing trusses shall comply with clause 3.2.5.1.

3.2.5.4.2 Assessment shall take into account all loadings incident on the escalator from adjacent infrastructure.

3.2.5.4.3 Where the structure fails to comply with the assessment criteria the structural integrity of the truss shall be reinstated for the remaining life of the escalator.

3.2.5.4.4 The truss shall have a fatigue life consistent with the residual design life of the escalator.

3.2.5.4.5 The assessment shall demonstrate how the integrity of the truss, ancillary structural components and surrounding infrastructure have been achieved taking into account any deterioration or damage.



3.2.5.5 Truss restrictions

No post installation modification or alteration of the truss members shall be carried out without an assured structural assessment.

3.3 Steps, pallets

3.3.1 General

3.3.1.1 Every step introduced onto the LU Network shall have a unique number to assist with In-Service Management and regular examination of escalator step assemblies as described in Attachment 5. The unique number requirement is not applicable to moving walk pallets.

3.3.2 Dimensions

3.3.2.1 General

3.3.2.1.1 Escalator step width shall be nominally 1m.

3.3.2.1.2 Moving walk pallet width shall be as defined in LU Standard S1371 Station Planning.

3.3.3 Structural design

3.3.3.1 General

3.3.3.1.1 The requirements for escalator steps have been incorporated into Attachments 3, 4 and 5. These attachments form a complete technical standard, against which replacement steps shall be type-approved, purchased and inspected.

3.3.3.1.2 The data gathered from the tests as described in BS EN 115-1 and Attachment 3 shall be used in the Whole Life Cost Plan called for in clause 3.1.6.4.

3.3.3.1.3 For pallets, the Supplier shall commission an FEA model to address all the load cases defined in BS EN 115-1. The results shall be submitted to LU for approval.

3.3.3.2 Step and pallet testing

3.3.3.2.1 New designs of escalator steps shall meet the type approval requirements of Attachment 3.

3.3.3.2.2 Pallets shall be subjected to type approval tests to BS EN 115-1. The torsional test, where applicable, shall be carried out as described in BS EN 115-1, Annex F:F.3 Torsional test 2. A test report shall be submitted to LU.

3.3.3.2.3 Each escalator and moving walk shall undergo an annual step and pallet assembly non-destructive examination in accordance with the requirements of Attachment 5.

3.3.4 Guiding of steps and pallets

At the time of commissioning of a new or refurbished escalator, where guidance of the step is achieved by the wheels or step chain, the clearance between the sides of the steps and the adjacent skirting shall be between 1mm and 3mm, and the sum of the clearances at both sides shall not exceed 5mm. Where the skirting of moving walk finishes above the pallets, the requirements of BS EN 115-1 clause 5.5.5.2 shall be met.

3.3.5 Clearance between steps and pallets

3.3.5.1 At the time of commissioning of a new or refurbished escalator, the clearances between treads of adjacent steps, and between treads and risers of adjacent steps,



shall be between 1mm and 4mm. The clearance gaps shall be equal at both left and right hand sides of the steps.

- 3.3.5.2 At the time of commissioning of new or refurbished moving walk, the clearance between treads of adjacent pallets shall not exceed 4mm.

3.4 Drive unit

3.4.1 Design of drive unit components

3.4.1.1 General

- 3.4.1.1.1 The individual integrity of all driving elements shall have a safety factor of at least 5 for static calculations. This safety factor is determined as the ratio between the breaking force based on the ultimate tensile strength or, shear strength of the component material and the static force to which the component is subjected when the escalator carries a rated load of 5kN/m^2 per exposed step, together with the weight of the components and the tension force of the tensioning device.

- 3.4.1.1.2 The duty rating loading when determining fatigue and wear out of driving elements shall be taken at a minimum of 120kg per exposed step and 125kg per exposed pallet.

- 3.4.1.1.3 The duty ratings mentioned above are not, of themselves, sufficient to define the demands of the mechanical and electrical components. In particular, in the case of mechanical components, operational life will be affected by structural fatigue and wear-out. Consequently, the design and associated calculations for all components and systems shall include the effect from:

- a) Start-ups;
- b) Variations in load arising from fluctuating customer flows;
- c) Variations in motor torque;
- d) Brake applications (including brake testing);
- e) All reasonably foreseeable faulted conditions (e.g. 'lock-ups' and step-to-comb collision).

- 3.4.1.1.4 The duty cycle on which the declared life of components is based shall allow for the following load cycle as a minimum, applied to each daily period of twenty four hours:

- a) 100% of duty rating load for 3.5 hours;
- b) 65% of duty rating load for 3.5 hours;
- c) 50% of duty rating load for 5 hours;
- d) 30% of duty rating load for 8 hours;
- e) 5% of duty rating load for 4 hours.

- 3.4.1.1.5 The drive assembly shall be mounted outside of the step band.

- 3.4.1.1.6 Where a drive chain is used the design and maintenance shall be such that the chain cannot touch the truss, tracking system or any unrelated component.

3.4.1.2 Speed

- 3.4.1.2.1 Where the escalators are replaced or refurbished, the speed shall remain unchanged. At new installation, the speed shall be defined following Ped-flow and Station evacuation analysis. The escalator shall be capable of running at a 'Stand-by' speed of nominally 0.2m/s.



3.4.1.2.2 A maintenance speed of nominally 25% of the normal running speed shall be provided.

3.4.2 Braking system

3.4.2.1 General

3.4.2.1.1 The braking system shall be fail safe.

3.4.2.1.2 Whenever a braking system is suggested that has not been approved for use previously on LU network, the logic and safety of the entire braking system shall be demonstrated by all of the following:

- a) Calculation;
- b) Formal risk assessment methodologies (e.g. HAZOP, FMEA);
- c) Load test.

3.4.2.2 Operational braking

3.4.2.2.1 The brake test load shall be 120kg passenger load per exposed step. The brake test load shall be 125kg passenger load per exposed pallet.

Note: Unlike mechanical braking, software controlled inverter braking provides deceleration to a pre-defined profile at variable loads, thus reducing the risk of individual or multiple customer falls.

3.4.2.2.2 When the escalator incorporates software controlled inverter braking the sampling frequency to determine the deceleration shall be a minimum of 10 samples per second.

3.4.2.2.3 When the escalator incorporates software controlled inverter braking, this facility shall revert to mechanical braking whenever software controlled inverter braking does not conform to a pre-determined deceleration profile.

3.4.2.3 Auxiliary brake

3.4.2.3.1 All escalators shall be equipped with an auxiliary brake, which shall be applied at all times while the escalator is stationary.

3.4.2.3.2 Immediate application of the auxiliary brake shall be required in the following situations:

- a) Over speed condition;
- b) Under speed condition;
- c) Failure of modulated (load dependent) braking system where fitted;
- d) Power failure.

Note: The requirements in b) and c) are in addition to BS EN 115-1 requirements.

3.4.2.3.3 When the escalator is being braked solely by the auxiliary brake, the Contractor shall by calculation and test demonstrate, that the escalator shall be brought to rest with a uniform deceleration and maintained stationary acting independent of operational braking.

3.4.2.4 Protection against risk of excessive speed and unintentional reversal of the direction of travel

Escalators and inclined moving walks shall be equipped in such a way that they stop automatically in the event of under speed detection, before the steps / pallets change from the pre-set direction of travel.

Note: This requirement is in addition to BS EN 115-1 clause 5.4.2.3 requirements.

3.4.3 Step and pallets drive

Clause 3.4.1.1.1 to 3.4.1.1.4 shall be applied to drive shafts and Idler shafts.

3.4.4 Step chain

3.4.4.1 Step band locking devices shall be provided. These locking devices shall be capable of sustaining the out of balance dead load of step band and rated load of 5kN/m² with a safety factor of 5, without the assistance of brakes. This safety factor is determined as the ratio between the breaking force of the locking device and the static force to which the locking device is subjected. An electrical interlock device shall be provided to prevent the escalator being started while the step band is mechanically locked.

3.4.4.2 The step chain shall be protected against kinking with an appropriate mechanical means. A means of system monitoring shall be provided.

3.4.4.3 The bearing pressure in the bush of the step chain shall not exceed 20 N/mm² under a load of 120kg per exposed step for escalator and 125kg per exposed pallet.

3.5 Balustrade

3.5.1 General

The balustrade including interior panels, decking and any outer panels shall form a rigid and total enclosure around the escalator.

3.5.2 Dimensions of balustrade

3.5.2.1 The decking panels shall be integrated with the adjacent station fabric or adjacent existing escalator or staircase.

3.5.2.2 The decking panels between two adjacent escalators shall be designed such that decking panels can be removed and replaced on one escalator without having to take the adjacent escalator out of service.

3.5.2.3 The balustrade and decking shall be designed and supported such that it can support a weight of 1000N applied over an area of 50mm x 50mm without any permanent deformation.

3.5.2.4 When a force of 500N is applied to the balustrade panels at any point of the panelling at right angles over an area of 50mm x 50mm, there shall be no gap greater than 1mm and no permanent deformation.

3.5.2.5 The balustrade shall be designed such that a force of 50N applied by hand, at the centre of a panel adjacent to any edge, shall deflect the panel by less than 0.5mm relative to the adjacent panel.

3.5.2.6 Balustrade panel and decking joints and mouldings shall be free of gaps with the potential to entrap buttons or fingernails.

3.5.2.7 Balustrade panel and decking joints and mouldings shall have no sharp edges liable to cause breakage of the skin.

- 3.5.2.8 Where balustrade access is required for any maintenance or cleaning activities the balustrade panels shall be removable without having to gain access from behind the panels.
- 3.5.2.9 Removable balustrade panels shall be designed such that the panel can be removed, handled and refitted by one person.
- 3.5.2.10 Panels shall be fixed so that they cannot become loose or fall out in service or be removed by customers.
- 3.5.2.11 The design of the balustrade shall permit the removal and replacement of the escalator handrails as an endless belt.

3.5.3 Anti Slide devices

Anti slide devices shall be provided on the escalator decking to BS EN 115–1 clause 5.5.2.2. The spacing of this shall be integrated with 'Stand on the Right, No Smoking' notices prescribed in clause 5.2.1.1 of this standard.

3.5.4 Skirting

- 3.5.4.1 The escalator step to skirting gap shall be protected by a brush guard mounted on the skirting panels. There is no requirement for the provision of brush guards on moving walk.
- 3.5.4.2 The depth of skirting panels shall be such that the loss of a wheel tyre and/or tread cleat shall not cause a visible gap to occur between the top of the step tread and the bottom of the skirting panel, at any point.
- 3.5.4.3 The skirting shall deflect no more than 2mm under a single force of 1500N acting at right angles over an area of 50mm x 50mm, at the most unfavourable point.
- 3.5.4.4 The skirting panels shall be stainless steel or painted black.
- 3.5.4.5 Skirting shall be smooth and vertical. Skirting joints shall have no sharp edges and shall be flush to within 0.5mm.
- 3.5.4.6 The brush guard shall be a double brush type with metal backed holder similar to the arrangement shown in Figure 1 below. The dimensions and clearances shall be as described in BS EN 115 -1 clause 5.5.3.4 c).

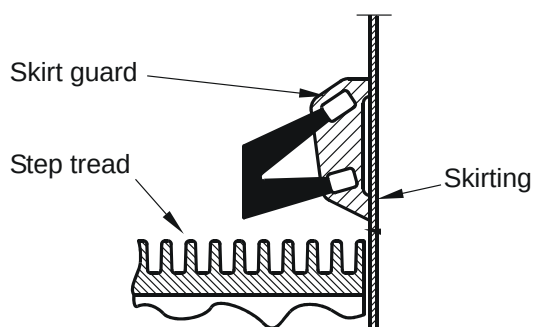


Figure 1 - Typical cross section through skirting and step tread showing skirt guard

- 3.5.4.7 The ends of the brush guard shall extend from a point 150mm +0/-10mm from each comb line, in the direction of the EWP (see Figure 2). The length of the extension shall be matching on both sides. The ends of the brush guard shall be tapered in both planes, over a length of 150mm.
- 3.5.4.8 The brush guard shall be designed such that it reduces the possibility of trapping a person's foot, or the wheels of baggage trolleys and similar devices. The brush guard

shall allow the outer comb sections to be lifted without removing the brush guard and it shall be possible to replace any part of the brush guard without dismantling the balustrade.

- 3.5.4.9 The skirt guard shall be positioned on the skirting so that the lower edge of the brush is as described in BS EN 115-1, Figure 1 and similar to the arrangement shown in Figure 2 below. The curved sections shall provide a smooth transition between the two.

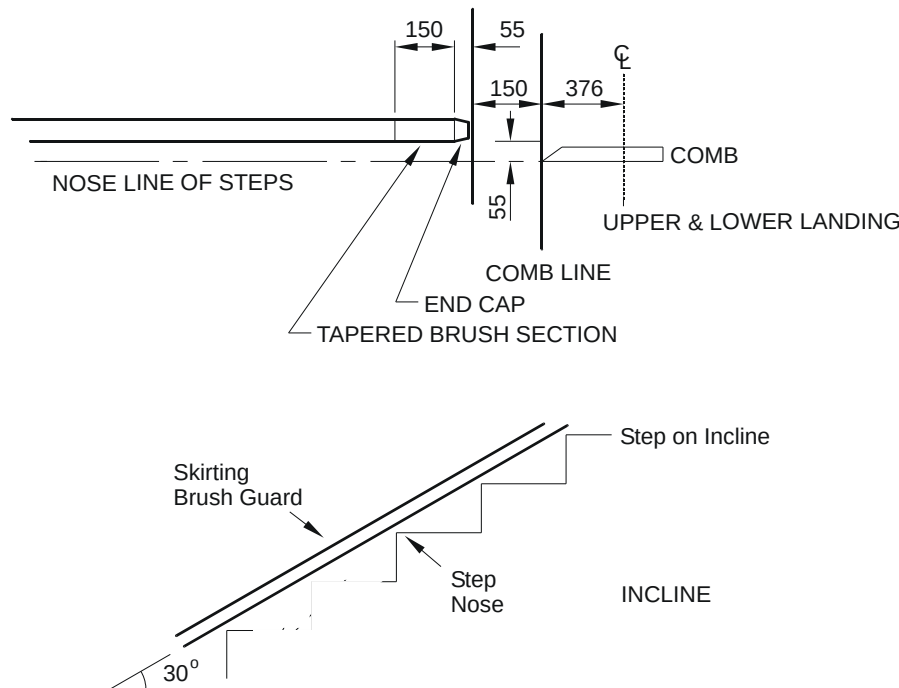


Figure 2 - Typical arrangement showing distance between comb line and skirt guard end cap

3.5.5 Newel end equipment

3.5.5.1 Newels shall include the following:

- Start up & start down key switches which will move the escalator up or down only when the "normal" mode is selected on the controller (refer to clause 3.12.2.1.4);
- Fixings for attaching an engineer's barrier;
- Retractable tape barriers – double sided "Danger No Entry" white lettering on red background;
- The escalator number, engraved on the front of one of each pair of newels. Characters shall be 75mm high and in New Johnston font, the engraving shall contrast visually with the surround;
- Lockable enclosures accessed by the existing common key arrangement across London Underground. This shall house an inspection control socket and power socket;
- The escalator manufacturer's name and 'CE' marking.

- 3.5.5.2 The numbering system of escalators on a station shall start at the lowest level escalators on the left when looking up from the bottom increasing to the right and upwards. Where there are escalators already existing on the Station, new escalators shall adopt the next consecutive number.

3.6 Handrail

3.6.1 General

- 3.6.1.1 The handrail system shall be synchronised with the step band within the limits of BS EN 115-1 under all conditions including stopping, starting & power failure.
- 3.6.1.2 Handrails shall be black in colour, except where stated otherwise in this Standard.
- 3.6.1.3 Circles of yellow colour (RAL 1003 Signal Yellow) integral with the handrail 18mm - 25mm in diameter shall be formed on the centreline of the outer surface. These circles shall be spaced at 1m intervals along the full length of the handrail. Circles adjacent to the handrail joint may be spaced between 0.5m to 1.5m.

3.6.2 Jointing

The tensile breaking load of any handrail joint shall be no less than 25kN.

3.6.3 Profile and position

- 3.6.3.1 The width of the handrail shall be no less than 75mm and no more than 85mm. At the time of commissioning of new or refurbished escalator, the sum total of the clearances between handrail lip and balustrade mouldings at any point on the escalator shall not exceed 6 mm as indicated in Figure 3.
- 3.6.3.2 The lower landing handrail track radius shall not be less than 2.4m.

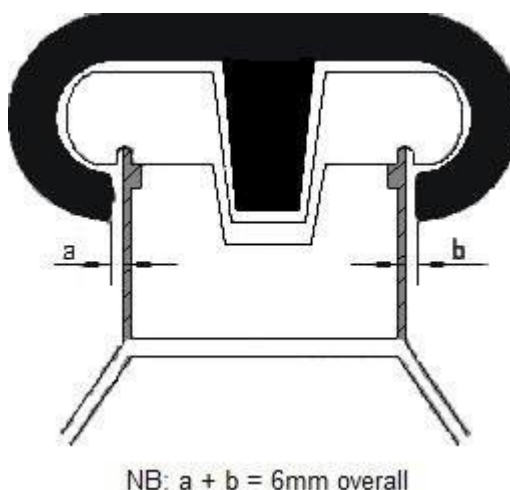


Figure 3 – Escalator handrail on balustrade moulding

3.6.4 Distance between the handrail centre lines

No additional LU requirement above that of BS EN 115-1 clause 5.6.3.

3.6.5 Handrail entry

The gap between the handrail and handrail moulding shall be less than 8mm to prevent possible finger traps.

3.7 Landings

3.7.1 Surface properties

The slip resistance on floor plates and trays shall achieve a Slip Resistance compliant with the requirement of LU Standard S1135 - Premises - Finishes.

Note: The LU requirement in general compares to the DIN 51130 mid range anti-slip requirement of R11.

3.7.2 Configuration of steps and pallets

3.7.2.1 Escalators

- 3.7.2.1.1 At the upper landing, the step nose shall travel horizontally for a minimum distance of 2.0m from the comb line, before vertical formation takes place (i.e. 5 flat steps).
- 3.7.2.1.2 At the lower landing, the step nose shall travel horizontally for a minimum distance of 1.2m from the comb line, before vertical formation takes place (i.e. 4 flat steps).
- 3.7.2.1.3 At landings, the height differential between adjacent steps shall be no more than 2mm and at flat landings each step shall be level within 2mm.
- 3.7.2.1.4 The radius of track curvature shall be not less than 3.6m at the upper landing and not less than 2.4m at the lower landing, passenger side. This requirement is not applicable to moving walk.

3.7.2.2 Moving Walks

- 3.7.2.2.1 The landings may be either horizontal or inclined to the same angle as the main part of the moving walk. Where the landing is horizontal, the pallet shall travel a minimum distance of 0.8m from the comb line, before entering the curve. On the horizontal and incline sections, the pallets shall be level within 2mm.
- 3.7.2.2.2 Where a change of inclination takes place, the radius of the running tracks shall be such that the gap between pallets shall not exceed the limits specified in clause 3.3.5.2 of this Standard.

3.7.3 Combs

No additional LU requirement above that of BS EN 115-1 clause 5.7.3.

3.7.4 Floor plates

- 3.7.4.1 Hinged floor plates shall be provided at each landing covering the area between the back of the comb plate and the end of the escalator truss. A means shall be provided (e.g. gas spring/strut) on each side to assist manual raising of the floor plate by a single person. A separate means shall be provided to secure the floor plate in the open position.
- 3.7.4.2 Floor plates shall be accurately levelled to each other and adjacent flooring.
- 3.7.4.3 Each floor plate shall have a fire resistance of thirty minutes as stipulated in the Fire Precautions Guidance document Bb001 Section 1, clause 7.1.2. The floor plate shall be type tested for fire resistance according to the requirements of BS 476-21 - Fire tests on building materials and structures.
- 3.7.4.4 Each floor plate shall be capable of supporting the greater of:
 - a) a total imposed load of 7.5kN uniformly distributed over the whole plan area of the plate;
 - b) a uniformly distributed load of 5kN per metre squared over the whole plan area of the plate.
- 3.7.4.5 The floor plates and supports shall be resistant to fatigue at the above loads.
- 3.7.4.6 The loads stated shall not cause:



- a) deflection by more than 3mm;
- b) deflection by an amount such that the clearance between the underside of the plate and the top of the escalator steps is reduced to less than 5mm;
- c) permanent deformation.

3.7.5 Floor trays

- 3.7.5.1 A maintenance access hatch measuring 2m x 1m shall be provided at both landings (upper and lower) for any equipment situated below passenger floor level that cannot be removed or replaced through the floor plates. This maintenance access shall be covered by floor trays.
- 3.7.5.2 Floor trays for escalators and moving walks shall conform to the Civil Engineer's requirements as referenced in the LU Standard S1053 Civil Engineering - Building and Station Structures.

3.8 Machinery spaces, driving and return stations

- 3.8.1 For building interface requirements (e.g. machinery spaces and noise limits; lighting and power) – see Attachment 1.

3.9 Fire protection

3.9.1 General

The Fire Precautions (Sub-Surface Railway Stations) Regulations together with the related Fire Precautions Guidance document Bb001 shall apply to all LU installations.

3.9.2 Cleaning

The cleaning performance shall comply with the requirements as stipulated in Attachment 6.

3.9.3 Dust trays

Provision shall be made for the collection and removal of detritus that falls from the step treads beneath both step return stations.

3.9.4 Drip trays

Provision shall be made for containment of lubricant loss, leakage, spillage and splatter to prevent unsafe conditions.

3.10 Transportation

No additional LU requirement above that of BS EN 115-1 clause 5.10. Site specifications need to consider the delivery of components to site.

3.11 Electrical installations and appliances

3.11.1 General

- 3.11.1.1 The escalator electrical system shall be designed to be compatible with a supply as described in BS EN 61000-2-4, class 3.



- 3.11.1.2 The escalator drive and control system shall be capable of withstanding a voltage drop of 30% for 400ms (or better), where the escalator is carrying passenger loads, not in excess of 50%.

Note: This is to enable the escalator to 'ride through' the vast majority of power system faults remote from the site.

- 3.11.1.3 The Escalators shall be fed from either the LU or DNO supply.
- 3.11.1.4 LU supplies are nominally 415V AC 3phase and neutral 50Hz. DNO supplies are nominally 400V AC 3phase and neutral 50Hz. The Supplier shall ascertain the nature of the supply characteristics.
- 3.11.1.5 Testing, inspection and certification shall be in accordance with the requirements of BS 7671, by an NICEIC or equivalent certified Contractor.
- 3.11.1.6 Examination, testing and certification of the electrical system shall be carried out every three years. The tests shall be restricted to the area downstream from the main escalator isolator. The tests shall include:
- a) measurement of the earth loop impedance value and fault current levels;
 - b) visual and physical checking of the integrity of the earthing and bonding connection and wiring;
 - c) measurement of the earth continuity of the whole installation. This shall include checking of the earthing and bonding of controller metallic handles and controller enclosures;
 - d) testing of the operation of RCD devices.

3.11.2 Supply

- 3.11.2.1 Where a new power supply or altered load is required LU Standard S1100 Load Change Application Requirements for Electrical, Compressed Air and Other Services shall be applied.
- 3.11.2.2 The escalator drive system shall regenerate into the supply when it is travelling under load in the down direction.
- 3.11.2.3 When utilising regenerating drives, appropriate co-ordination shall take place between the drive supplier and the LU power supply designer to ensure power quality is not adversely affected.
- 3.11.2.4 The escalator control system shall include a power supply healthy light.
- 3.11.2.5 A single point of local isolation for the main incoming escalator supply to the machine room shall be provided in the machine room. This shall allow for the safe working on the escalator without reliance on isolation by a third party.
- 3.11.2.6 The electrical supply to each escalator shall be interlocked by the use of a unique coded London Underground Castell key system. See Table 2 below. The allocation of these numbers shall be managed by LU.

LU Lines	Key Numerics
Bakerloo, Central and Victoria Lines	Alpha-Alpha-Numeric
Jubilee, Northern and Piccadilly Lines	Alpha-Numeric-Alpha
Sub Surface Lines	Numeric-Alpha-Alpha

Table 2 – Conversion table for London Underground Castell key system

3.11.2.7 The mechanical locking off system shall facilitate addition of padlocks. A hasp shall be fitted to facilitate addition of multiple padlocks.

3.11.2.8 Insulating mats shall be provided in front of all the access door(s) of electrical equipment.

3.11.3 EMC & harmonics

3.11.3.1 The Supplier shall comply with the requirements regarding Electromagnetic Compatibility (EMC) and harmonics specified in this Standard.

3.11.3.2 The escalator equipment and installation shall comply with Standard S1222 with regard to Electromagnetic Compatibility (EMC).

Note: Both LU and DNO supplies are nominally 400V AC 3phase 50Hz, with each supply having its own separate Standards and limits. The LU supply has inherently higher harmonic levels than the DNO.

BS EN 61000-4-13 provides further details of the levels of harmonics that are likely to be present in an industrial environment together with suitable test methods to demonstrate equipment immunity compliance. The 11th and 13th harmonics, which are derived from the LU DC traction system, could be marginally higher than the limits in BS EN 61000-2-4 Class 3.

3.11.3.3 Prior to installation, the existing harmonic distortion shall be measured and recorded at the electrical connection point. This shall determine both the suitability of the supply and the likelihood of compliance with ENA Engineering Recommendation G5/4-1 for a DNO supply and BS EN 61000-2-4 Class 3 for a LU supply, following connection of the additional escalator load.

3.11.3.4 Any measures (e.g. passive or active harmonic filtering etc) required to make the Supplier equipment operate properly on the provided supply shall be agreed with LU and implemented.

Note: For any installation that is delivered by LU the requirements of clause 3.11.3.3 & 3.11.3.4 shall be resolved and agreed prior to completing the tender of the assets and the measures required shall be included in the applicable specification.

3.11.3.5 The final installation, including the re-generation mode and multiple escalator operation, shall be tested to demonstrate compliance with ENA Engineering Recommendation G5/4-1 for a DNO supply and BS EN 61000-2-4 Class 3 for a LU supply or as agreed in clause 3.11.3.4.

3.11.4 IP rating

All electrical equipment shall be rated to a minimum of IP55 to BS EN 60529, with the exception of the following:

- a) High heat output components, which shall be rated at a minimum of IP54;
- b) Encoders, which shall be rated at a minimum of IP65;
- c) The escalators status indicator panel in the station operation room (if required), which shall be rated at a minimum of IP23;
- d) Passenger Emergency Stop Devices (full and half diamond).

3.11.5 Voltage limit for control and safety circuits

Where the safety line voltage is 50V or more, it shall be protected by a manually resettable 30mA residual current device.

3.12 Protection against electrical faults - controls

3.12.1 Protection against electrical faults

3.12.1.1 General

3.12.1.1.1 The Control system shall provide full control of the complete escalator electrical installation, including safety systems.

3.12.1.2 Electric Safety Devices

3.12.1.2.1 The step band locking device electrical interlock shall prevent the escalator from starting when in locked position.

3.12.1.2.2 The tension carriage safety device shall be manual reset type (i.e. requires reset at point of activation).

3.12.1.2.3 An emergency stop pushbutton shall be mounted on the truss at the location of each inching socket outlet, the contacts of which shall be wired into the safety line. Additional emergency stop pushbuttons shall be provided on the escalator incline at nominally 10m intervals.

3.12.1.2.4 In the case of central escalators in flights of 3 or more, emergency stop pushbuttons shall be mounted on the truss on the opposite side of the truss to the inch sockets, aligned with those described in clause 3.12.1.2.3.

3.12.1.2.5 Following the reinstatement of safety devices listed below there shall be no need to manually reset at the controller:

- a) Lower machine chamber isolator (where applicable);
- b) Passenger emergency stop switches;
- c) Emergency stop pushbuttons on the truss;
- d) Emergency stop on handheld inching device;
- e) Removal and reinstatement of the dummy plugs on the inching socket outlets.

3.12.1.2.6 In cases where the controller interfaces with the safety line for the purpose of monitoring the status of the safety devices or otherwise, the interface shall be designed to be fail safe and in accordance with the requirements of BS EN 60204-1. Where relays are used for interfacing, they shall be safety relays compliant with the principles of redundancy and self-checking in accordance with BS EN 60204-1.

3.12.2 Controls

3.12.2.1 Starting and making available for use

3.12.2.1.1 The following status information shall be provided at the front of the controller as a minimum:

- a) status of the power supply;
- b) stationary or running status, as well as the direction of running;
- c) passenger emergency stop device operated;
- d) engineer's stop device operated;
- e) tripping of any safety devices, in addition to c) and d), clearly stating which safety device caused the tripping;



- f) operation of any protective device that would cause automatic stopping of the escalator or prevent restarting, clearly stating the cause of the stoppage.

3.12.2.1.2 The following status & alarm information shall be provided in the station operations room:

- a) indication of direction of running of the escalator;
- b) audible alarm and visual indication of any unplanned stoppage of an escalator;
- c) Power on;
- d) Passenger emergency stop operated.

3.12.2.1.3 A volt free pair of contacts shall be made available for the CCTV interface coverage required in LU Standard S1147 Surveillance & Security Systems.

3.12.2.1.4 The following features shall be available with the controller:

- a) a single selector switch on the front of the controller from where the escalator can be switched between 'Normal', 'Test' and 'Inch' mode;
- b) 'Up' and 'Down' pushbuttons on the front of the controller which will move the escalator up or down respectively only when the 'Test' mode is selected.

3.12.2.1.5 The escalator control system shall include the facility for slow speed operation during intermittent passenger usage. The system shall be fail safe. On detection of the passenger activity, the escalator shall accelerate to its normal speed. The escalator shall decelerate automatically to 0.2m/s, for stand-by operation, following no detection of passenger movement onto the escalator for an adjustable period of time. Acceleration and deceleration shall be less than 0.5m/s². An Engineers override facility shall be incorporated within the control system.

3.12.2.2 Stopping

3.12.2.2.1 Passenger Emergency Stop Devices shall be provided to LU drawings 584-943 and 584-949, depicted in Figure 4 'diamond' and Figure 5 'half diamond'.

3.12.2.2.2 During installation of new escalator(s), the Passenger Emergency Stop Devices installed shall be 'half diamonds', with the exception defined in clause 3.12.2.2.7 below. During major escalator refurbishment, the Passenger Emergency Stop Devices shall be as the existing 'diamond'/'half diamond' arrangement, except as defined by clause 3.12.2.2.4. A 'diamond' shall be fitted in lieu of a 'half diamond' on upper and lower decking to suit whenever justified by site-specific accessibility (such as when accessible from a walkway alongside the escalator landing length).

3.12.2.2.3 Passenger Emergency Stop Devices shall be fitted on the left and right hand side, at the top and bottom of the escalator, approximately in line with the comb, with push panels facing the escalator.

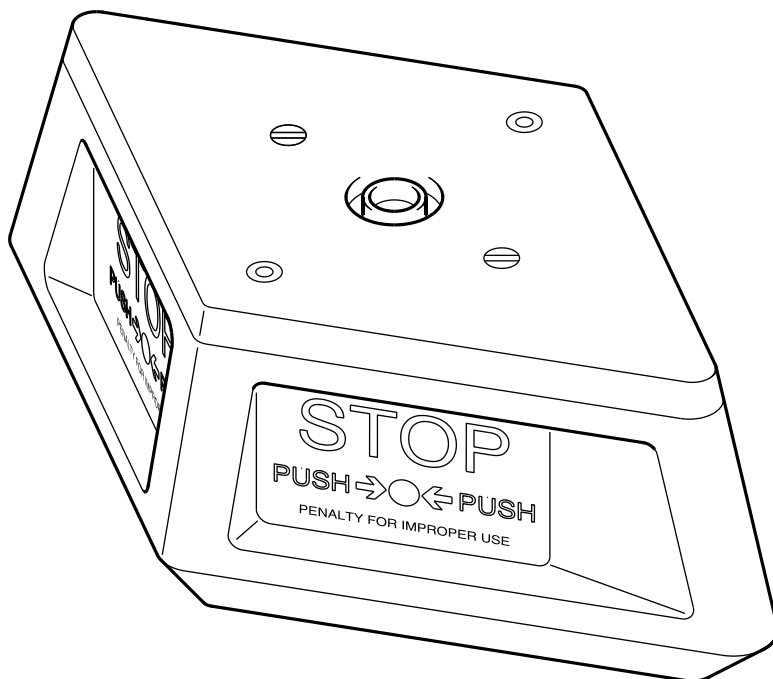


Figure 4 - Typical escalator stop device - full 'diamond'

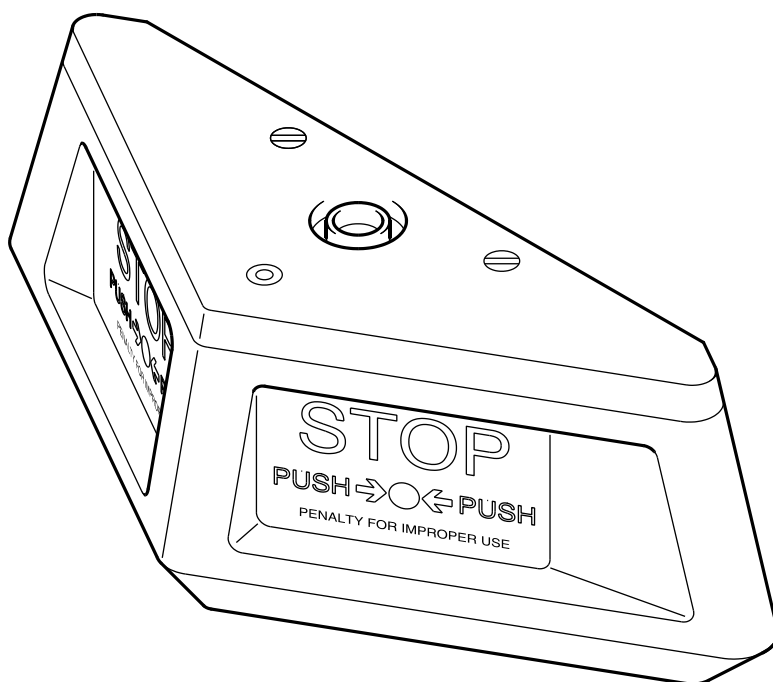


Figure 5 - Typical escalator stop device - half 'diamond'

3.12.2.2.4 If the escalator is above 10m rise, additional Passenger Emergency Stop Devices shall be fitted on the incline balustrade decking as appropriate. The following shall apply:

- a) The number of devices on the incline shall be as shown in Table 3 below.
- b) The exact spacing shall be arranged such that the position of the devices does not coincide with decking panel joints.

Rise	No. of devices on the incline
less than 10m	0
from 10m but less than 12.5m	2 (1 on either side of step band)
from 12.5m but less than 18m	4 (2 on either side of step band)
from 18m but less than 24m	6 (3 on either side of step band)
From 24m but less than 30m	8 (4 on either side of step band)

Table 3 - Additional Passenger Emergency Stop Devices

3.12.2.2.5 The space between Passenger Emergency Stop Devices and the handrail shall be not less than 150mm, and no greater than 500mm.

3.12.2.2.6 Where 'half diamonds' are fitted between two escalators, each pairing shall be aligned.

3.12.2.2.7 Where a fixed staircase is located adjacent to an escalator, 'diamonds' shall be fitted, aligned with the Passenger Emergency Stop Devices on the opposite side of the escalator, with the exception defined in clause 3.12.2.2.8 below. All 'diamond' push panels shall be arranged to stop the adjacent escalator.

3.12.2.2.8 Where the decking between the escalator and fixed staircase is greater than 1400mm measured between the escalator handrail and the edge of the staircase, 'half diamonds' shall be fitted, with push panels facing the escalator and aligned with the 'half diamonds' on the opposite side of the escalator.

3.12.2.2.9 When the push panel of the passenger emergency stop Device is operated, it shall remain in the pushed position. The red LED (in the lid) shall illuminate and remain illuminated until the push panel is reset. The panel shall be released mechanically, by turning a key in the lid of the device housing.

3.12.2.3 Reversal of direction of travel

No additional LU requirement above that of BS EN 115-1 clause 5.12.2.3.

3.12.2.4 Restarting

No additional LU requirement above that of BS EN 115- 1 clause 5.12.2.4.

3.12.2.5 Inspection control

3.12.2.5.1 The escalator shall be equipped with inspection controls to allow operation during maintenance or inspection by means of portable and manually operated devices.



- 3.12.2.5.2 The portable manually operated control device shall have a 5 metre long lead and the control unit outlet sockets shall be positioned at the following locations:
- a) controller cabinet door;
 - b) upper landing truss;
 - c) within the machine room at the transition between the incline and upper landing, on one, common side;
 - d) within the machine room at the transition between the incline and lower landing, on one, common side;
 - e) lower landing truss;
 - f) upper newel (behind lockable enclosure);
 - g) lower newel (behind lockable enclosure).
- 3.12.2.5.3 All inching socket outlets shall be fitted with dummy plugs to maintain the continuity of the escalator safety line.
- 3.12.2.5.4 The escalator shall only operate during inching, when the inch button and either the up or the down button on the handheld unit are pressed. When the up and down buttons are pressed simultaneously, the escalator shall remain inoperative, that is they shall be electrically interlocked. Upon release of any of the buttons the escalator shall stop.
- 3.12.2.5.5 The 'inch', 'up' and 'down' buttons shall be disabled while the latching 'stop' button is depressed i.e. - the safety line shall be made up before the controller start sequence can commence.
- 3.12.2.5.6 With an inching pendant plugged in it shall not be possible to start the escalator in 'normal' or 'test' mode.
- 3.12.2.5.7 Selection of 'normal' or 'test' mode with an inching pendant plugged in shall display an appropriate message at the controller and inhibit a start command.
- 3.12.2.5.8 The Contractor shall demonstrate that the portable handheld inching control device is either safely compatible with, or not physically interchangeable with, other LU escalator inching devices (see clause 3.12.2.5.9 below)
- 3.12.2.5.9 The LU standard portable handheld inching control device, described in clause 3.12.2.5.8, connects via a plug, to a 10 pin socket with plug/socket pin number allocation as described in Table 4 below.

Pin number	Device
1	Stop pushbutton connection
2	Stop pushbutton connection
3	Link to pin 4
4	Link to pin 3
5	Ready indicator connection
6	Ready indicator connection
7	Feed to 'Inch' (common/run) pushbutton
8	'UP' signal from 'UP' pushbutton
9	'DOWN' signal from 'UP' pushbutton

Table 4 – Inch device pin number allocation



3.12.2.5.10 The inching control device shall include an 'inch' (common/run) pushbutton.

3.12.2.6 Software

3.12.2.6.1 Software change control shall comply with LU Standard S1210 Safety-Related Software. A secure software change control procedure shall be adopted.

3.12.2.6.2 The requirements of LU Standard S1096 Control of Lift and Escalator Controller Software shall be met.

3.12.2.6.3 Where brake control and speed detection systems are dependant on software, then the system must give at least the level of inherently fail safe security as conventional systems by defaulting to mechanical braking sequences and performance.

3.12.2.6.4 Where a software dependant device is implemented as part of a safety circuit then redundancy, diversity and self-checking for both hardware and software shall be provided. The system must default to a condition providing a level of security equivalent to that of a conventional hard wired electromechanical fail-safe system.

3.13 Passenger side guarding

3.13.1 General requirements

3.13.1.1.1 For maintenance purposes, the following barriers shall be provided to prevent access by unauthorised personnel and the Contractor shall implement safe systems of work:

a) Where floor plates are not raised, lockable Maintenance Engineers' barriers shall be provided across the newel ends. One barrier shall be provided, to LU drawing 34-905, for each of the upper and lower landings, per flight of escalators;

b) Where floor plates are to be raised on the passenger side, a lockable barrier shall surround the escalator working area. The barrier shall give 300mm minimum working space either side of the floor plate opening, 600mm minimum working space behind the opening and a minimum height of 1100mm. The design of the barrier shall meet all operational and safety requirements and be submitted to LU for acceptance. One barrier shall be provided for each of the upper and lower landings, per flight of escalators.

Note: As a consequence of barriers being in place, the escalator will not be available as a stairway or route for evacuation.

Note: Operational Staff will not be expected to deploy floor plate barriers. This is solely the responsibility of the maintainer.

3.13.1.1.2 The floor plate barriers described in clause 3.13.1.1.1b) above shall be stored at the designated locations, as described in clause 1.8 of Attachment 1.

3.13.1.1.3 Agreed procedures shall be followed under circumstances where a gap is left in the machine (i.e. steps have been removed) when the machine is left unattended for either short or prolonged durations.

3.13.1.1.4 When deploying barriers, the following practices shall be adopted to mitigate risk:

- a) Engineer's barriers and floor plate barriers shall be secured in place;
- b) The floor plate barrier shall be put in place before the floor plate is lifted;
- c) Movement of barriers shall be undertaken in accordance with manual handling guidelines and risk assessment;



- d) The erection of barriers around floor plates shall be undertaken in accordance with an agreed works instruction, taking into consideration the risk to passengers and the engineer;
- e) The escalator shall not be left unattended whilst floor plates are lifted, even when maintenance barriers are in place;
- f) Safe systems of work shall be used in accordance with the escalator suppliers Operation and Maintenance (O&M) manuals, maintainers method statements and the site specific Risk Assessments.

3.13.2 Risk Assessment

- 3.13.2.1.1 A Risk Assessment shall be carried out for each new/replacement installation and formally accepted by the responsible LU key stakeholders. All activity risks shall be eliminated or demonstrated to be ALARP.
- 3.13.2.1.2 When the floor plate barriers are put in place, this has potential, at certain locations, to have a detrimental impact on passenger flows. As a consequence, arrangements need to be established as to when the barriers can be deployed.
- 3.13.2.1.3 The impact of fitting floor plate barriers in operational hours, on the station fire strategy shall be evaluated and formally accepted by the responsible LU key stakeholders.

4 Verification of the safety requirements and/or protective measures

- 4.1 Compliance with the requirements of this standard shall be demonstrated to LU by each party contracted to LU. Additionally LU may audit compliance as part of its surveillance regime.

5 Information for use

5.1 General

No additional LU requirement above that of BS EN 115-1 clause 7.1.

5.2 Signs and Notices

5.2.1 Plates inscriptions and notices for use

- 5.2.1.1 'Stand on the Right, No Smoking' notices to LU drawings 36-913 and 36-917 as appropriate shall be mounted on the centre decking panels between adjacent escalators space at maximum 8m centres. Where lateral clearance requirements preclude the use of fittings in accordance with these drawings, equivalents may be used subject to approval by LU.
- 5.2.1.2 Signs shall not be placed within 1.0m of a passenger emergency stop device.
- 5.2.1.3 Where the decking at the side of an escalator is over 750mm in width, notices shall be fitted in a position corresponding to those on the centre decking.
- 5.2.1.4 The notices shall be fixed to the steelwork below the decking and not to the decking panels only.



5.2.1.5 Safety critical signage applicable in machine chamber shall be fitted as described in Table 5.

Note: 'X' is the station escalator number.

LOCATION	TEXT and LOCATION
Switchboard / Isolator cabinet	'SWITCHBOARD No X' / 'ISOLATOR No.X'
Drive cabinet	'DRIVE No X'
Controller cabinet	'CONTROLLER No X'
Escalator truss (upper & lower)	'x'
Drive motor	Arrow with 'UP' and 'DOWN' text indication direction of travel.
Escalator truss (upper landing)	'STEP BAND LOCKING DEVICE'
Manual control switches	Manual control switches shall have clearly worded labels detailing their function, or functions relating to their various settings
Isolator (handle)	'ISOLATOR', 'ON', 'OFF'
Indicators	Clearly labelled as appropriate for use.
Oil granules bin	See L&E Drawing No. 384-950
Machine guards	Clearly numbered as on wall drawing layout plan
Guard storage area	'AUTHORISED, GUARD STORAGE AREA'
'Fire Point' (F001, F002, F003)	L&E Drawing No. 384-948: Above machine room fire fighting equipment.
'Unauthorised Access Prohibited' (P004) 'Report to Operation Room/Station Supervisor for Permit (M001)	L&E Drawing No. 384-952: On the outside of machine room access doors and hatches.
'CAUTION – Door Opens onto Passenger Concourse' (W001)	L&E Drawing No. 384-954: On the inside of machine room access doors or hatches that open directly onto to a passenger area.
'Keep Machine Room Clean' (M001)	L&E Drawing No. 384-958: Near machine room entrance door.
'Mind the Step' (W001)	L&E Drawing No. 384-959: Where there is an unexpected step.
'DANGER- Moving Machinery' (W001) 'Unauthorised Access Prohibited' (P004)	L&E Drawing No. 384-960: On dust tray doors.
Treatment of electric shock	L&E Drawing No. 384-962: Local to electrical equipment cabinets.
'DANGER – Moving Machinery' (W001) 'Unauthorised Access Prohibited' (P004)	L&E Drawing No. 384-967: Machine room side of incline access gates. Maintenance Engineers' barriers.
Flammable material store – Authorised contents	L&E Drawing No. 384-968: Inside of flammable material store lid.
'Limits of Permit to Enter Zone'	L&E Drawing No. 384-969: Wall of machine room where shared between two different permit zones.
'Flammable Material Store' (W021) 'L&EE Authorised Contents only' (M001)	L&E Drawing No. 384-970: Outside of flammable material store.
'EXIT' (E001, E002 – With arrows when required)	Wherever required to indicate the nearest machine room authorised exit route. To BS 5499.



LOCATION	TEXT and LOCATION
'No Exit'	At the entrance to any passageway that does not lead to an exit route.
Guard location diagram (size 610 x 508mm)	On the upper and lower machine chamber wall

Table 5 - Table of signs

5.2.2 Advertising

The escalator shall not bear any advertising apart from designated advert panels.

5.3 Design, examination, testing and maintenance

5.3.1 Design process

5.3.1.1 The escalator shall be safe, reliable, and fit for the purpose of operating at its intended duty cycle. All safety risks shall be eliminated or demonstrated to be ALARP.

5.3.1.2 Throughout this standard, design and review shall apply to new escalators and to any modifications to existing escalators.

5.3.1.3 The design of escalators shall be:

- a) planned and managed in accordance with a formal, structured, documented and auditable process;
- b) undertaken by competent personnel.

5.3.1.4 The design process shall consider, in respect of each system or component:

- a) its physical arrangement;
- b) its defined interaction with other components and systems;
- c) its intended usage;
- d) the process and documentation associated with maintaining it within its prescribed operating limits.

5.3.1.5 The design process shall take account of the full life cycle of the escalator including:

- a) installation;
- b) testing and commissioning;
- c) hand-over and acceptance;
- d) maintenance;
- e) refurbishment and re-commissioning.

5.3.1.6 Each escalator shall be provided with the following keys as required:

- a) a unique Castell key for isolation of the main incoming power;
- b) a key to open the escalator controller and associated panel doors;
- c) Newel start key.

5.3.2 Design reviews

5.3.2.1 Planned design reviews shall be:

- a) conducted at all stages of the design;
- b) notified sufficiently in advance to allow LU or its representatives to participate.

5.3.2.2 The design reviews shall include:

- a) ensuring that the requirements for the design have been comprehensively captured;
- b) compliance with the requirements including performance, safety, reliability, operability and maintainability;
- c) design calculations for their accuracy, applicability and comprehensiveness;
- d) feedback as a result of any testing and previous performance issues;
- e) as a result of d) identification of any areas where the design could be improved.

5.3.2.3 Proposed changes to the design, configuration or usage of the escalator shall occur only with documented formal approval, via the LU ECR process for operational assets, assessed against the current design, or project design approval process for new assets.

5.3.3 Reliability and maintainability

5.3.3.1 The design of the escalator shall allow for ease of all maintenance and servicing activities. As far as is reasonably practicable, all items that need to be routinely removed for maintenance or replacement shall be capable of being removed without disturbing other systems.

5.3.3.2 The design of the escalator shall be reviewed to determine any areas that require life cycle and /or supplementary testing to limit the reliability risks with new or unproven designs or to demonstrate the suitability of the design in its intended application.

5.3.4 Examination and Tests

5.3.4.1 Prior to entry into passenger service of a newly installed escalator, or after major refurbishment, the escalator shall be proof run for a continuous 24hour period, 12hours in each direction. For major modifications the escalator shall be run for a duration appropriate to the modification undertaken, but not less than 4 hours in each direction. The escalator shall also undergo an examination in accordance with Attachment 8.

5.3.4.2 Full load brake tests shall be carried out following any disarrangement of the braking system unless the effectiveness of the braking system can be demonstrated by other means.

5.3.5 Maintenance - General

5.3.5.1 Information relating to factors that may adversely affect performance and safety and which is relevant to common escalator equipment and components on the LU network, shall be made available to LU, to enable the design to be modified, if required, and other maintainers, who may be affected, to be informed.

5.3.5.2 The escalator shall undergo six-monthly examinations in accordance with Attachment 8.



5.3.5.3 The escalator shall undergo an annual full condition assessment in accordance with Attachment 7.

5.3.5.4 The escalator shall undergo supplementary tests as called for by the competent person based on their risk assessment of the escalator and escalator equipment in line with the Safety Assessment Federation (SaFed) "Guidelines on the Supplementary Tests of In-Service Escalators".

5.3.6 Escalator maintenance regime

5.3.6.1 The escalator maintenance regime shall be managed to deliver the following:

- a) to optimise the design life of the equipment;
- b) achievement of availability and reliability targets set by the business;
- c) maintenance of an acceptable passenger environment and ambience, as per the targets set by the business, throughout the life of the escalator;
- d) maintenance of asset condition above those as defined by the FM45 criterion;
- e) safe escalator operation.

5.3.6.2 The maintenance regime shall be established following a structured analysis (which may include use of data on similar equipment used elsewhere under a similar operating context as a template) of:

- a) escalator design;
- b) service requirements, including reliability metrics, such as MTBF, MTTR;
- c) operating environment;
- d) maintenance environment;
- e) age of escalator;
- f) historical data;
- g) O&M requirements.

5.3.6.3 The maintenance regime shall be submitted for review and acceptance by LU key stake holders.

5.3.6.4 In determining the maintenance regime, the following shall be established and declared:

- a) the operational context;
- b) the philosophy of maintenance over the life of the escalator;
- c) the maintenance procedures and tests to be performed;
- d) the standards to be achieved.

5.3.6.5 Alterations to any part of the escalator maintenance regime shall:

- a) be subject to a change control process and be documented;
- b) not be implemented until their implications have been considered and formally accepted by the responsible LU key stakeholders.



5.3.6.6 Prior to the entry of new or modified escalators into service the following requirements shall be satisfied:

- a) LU operational staff shall be adequately trained in the safe operation of the escalator;
- b) a maintenance contract shall be in place to maintain the escalators in a safe and reliable condition;
- c) the maintenance regime shall be fully documented.

5.3.6.7 The maintenance regime shall be reviewed not less than once every three years, or after any change of maintenance contractor, and updated as required, to take account of escalator performance and usage.

5.3.6.8 The intervals between maintenance visits shall be determined in accordance with 5.3.6.1 to 5.3.6.7.

5.3.7 Competence of staff

5.3.7.1 All staff undertaking the maintenance of the escalators shall be:

- a) trained and have sound knowledge of local work instructions;
- b) competent to undertake the tasks allocated to them;
- c) licensed for safety critical tasks;
- d) subject to adequate supervision / management to ensure that only staff who are competent carry out the specific maintenance tasks;
- e) subject to a monitoring process.

5.3.7.2 The person responsible for the acceptance and sign-off of any work carried out on an escalator shall be identified.

5.4 Training

5.4.1 For all new installations the supplier shall:

- a) develop a training module on the safe use and operation of the escalator for station staff and LU trainers;
- b) provide an on site training course in the safe use and operation of the escalator to station staff and other nominated staff.

5.4.2 Where an escalator is modified or refurbished, 5.4.1 shall apply in respect of any changes.

5.5 Operational and maintenance information

5.5.1 A site specific operational and maintenance manual shall be provided. In addition to complying with BS EN 13015 it shall include as a minimum the following:

- a) clear table of contents;
- b) full contact detail of the supplier;
- c) technical particulars (e.g. adjustments, replacements, setting-up);
- d) Users handbook;

- e) Operators handbook;
- f) escalator owners instructions;
- g) care recommendations;
- h) fully detailed spares information including source of spares;
- i) instructions for the adjustment and maintenance of all safety components and other major equipment items;
- j) circuit diagrams;
- k) Declaration of conformity with BS EN 115-1, the EMC Directive and contract documentation.

5.6 Accompanying documents (in particular instruction book)

5.6.1 The following shall be provided and maintained throughout the life of the asset:

- a) Operation and Maintenance (O&M) manuals;
- b) Complete suite of assembly and component piece part drawings with parts list and manufacturing process details;
- c) A Safe Use and Operations Manual.

5.6.2 The documents shall be written in the English language. Where drawings and other data emanate from a non-UK source, an accurate translation shall be provided.

5.6.3 The requirement of 'A Safe Use and Operations Manual' shall be consistent with the LU Rule Book 9.

5.7 Marking

5.7.1 No additional LU requirement above that of BS EN 115-1 clause 7.5 and the requirements of clause 3.5.5.1d), 3.5.5.1f) and 5.2.1.5 of this Standard.

6 Responsibilities

The Head of Technical Discipline – L&E (Lift and Escalator) has the responsibility for the technical content of this Standard.

The Asset Manager – shall be responsible for ensuring that the condition of lift, escalator and moving walk is fully understood at all stages of its life and appropriate budget provision is made to maintain the L&E assets in a fit to use condition, compliant with the requirements of agreed maintenance regime.

7 References

7.1 General

References in the text are made to latest editions unless specific editions are cited.

Note: References to particular EC Directives and Regulations, Acts of Parliament, Statutory Instruments or Common Law are made only if the subject demands them. Users of engineering standards are bound by all the relevant requirements of the law, regardless of whether or not there is any reference to them in the standards.

7.1.1 Statutory documents

Title
Electromagnetic Compatibility Directive
The Supply of Machinery (Safety) Regulations
The Supply of Machinery (Safety Amendment) Regulations

7.1.2 British, European and International Standards

Document no.	Title
BS 476-21	Fire tests on building materials and structures. Methods for determination of the fire resistance of loadbearing elements of construction
BS 7608	Guide to fatigue design and assessment of steel products
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS 7801	Escalators and moving walks. Code of practice for safe working on escalators and moving walks
BS 8300	Design of buildings and their approaches to meet the needs of disabled people. Code of practice.
BS EN 115-1	Safety of escalators and moving walks Part 1: Construction and installation
BS EN 115-2	Safety of escalators and moving walks Part 2: Rules for the improvement of safety of existing escalators and moving walks
BS EN 13015	Maintenance for lifts and escalators. Rules for maintenance instructions
BS EN 1993-1-9	Eurocode 3. Design of steel structures. Fatigue
BS EN 1999-1-3	Eurocode 9. Design of aluminium structures. Structures susceptible to fatigue.
BS EN 60204-1	Safety of machinery. Electrical equipment of machines.
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 61000-2-4	Electromagnetic compatibility (EMC). Environment. Compatibility levels in industrial plants for low-frequency conducted disturbances
BS EN 61000-4-13	Electromagnetic compatibility (EMC). Testing and measurement techniques. Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests
BS ISO 18738-2	Measurement of ride quality: Escalators and moving walks
PD 5304	Guidance on safe use of machinery

7.1.3 LU company documents

Document no.	Title
LU Rule Book 9	Lifts, escalators and moving walkways
S1053	Civil Engineering - Building and Station Structures
S1066	Lighting of London Underground Assets
S1085	Fire Safety Performance of Materials – Stations and Tunnel Infrastructure
S1092	Escalators and Passenger Conveyors
S1096	Control of Lift and Escalator Controller Software
S1100	Load Change Application Requirements for Electrical, Compressed Air and Other Services
S1135	Premises – Finishes
S1147	Surveillance & Security Systems
S1210	Safety - Related Software
S1222	Electromagnetic Compatibility (EMC)
S1371	Station Planning



Document no.	Title
S1622	Glossary of terms and abbreviations
G1352	Maintenance Scaffolding on Escalators and Moving Walks
Bb001	Fire Precautions Guidance Document

7.1.4 Other

Document no.	Title
EMW	SAFed. Guidelines for the safe operation of escalators and moving walks
Railway Safety Principles and Guidance	HSE Publications. HM Railway Inspectorate
HSE Guidance Note PM 34	Safety in the use of escalators
HSE Guidance Note PM 45	Escalators periodic thorough examination
G5/4-1	Electricity Association Engineering Recommendation G5/4-1

7.1.5 LU Drawings

Document No.	Title
34-905	Maintenance Barrier
36-913	Cast Aluminium Base for 'Stand on Right' notice
36-917	Cast Aluminium Base for 'No Smoking' notice
384-948	'Fire Point'
384-950	Oil granules bin
384-952	'Unauthorised access prohibited'
384-954	'CAUTION – Door Opens into Passenger Concourse'
384-958	'Keep Machine Room Clean'
384-959	'Mind the Step'
384-960	'DANGER – Moving Machinery'
384-962	Treatment of electric shock
384-967	'DANGER – Moving Machinery'
384-968	Flammable material store – Authorised contents
384-969	'Limits of Permit to Enter Zone'
384-970	'Flammable Material Store' 'L&EE Authorised Contents only'
584-943	Escalator Stop Switch 'Full Diamond'
584-949	Escalator Stop Switch 'Half Diamond'

7.2 Abbreviations

The following abbreviations are created:

- a) within London Underground's Glossary of Terms (S1622);
- b) from published sources that are clearly identified.

Abbreviation	Definition	Source
ALARP	As Low As Reasonably Practicable	a
CCTV	Close Circuit Television	a

Abbreviation	Definition	Source
DNO	Distribution Network Operation	a
ECR	Engineering Change Request	a
EMC	Electromagnetic Compatibility	a
EWP	Erection Working Point	a
FEA	Finite Element Analysis	a
FFT	Fast Fourier Transform (spectral analysis)	b
FMEA	Failure Modes and Effects Analysis	a
HAZOP	Hazards and Operability Study	a
IP	Ingress protection	a
ITP	Inspection and Test Plan	a
L&EE	The Lift and Escalator Engineer	a
LFEP	London Fire and Emergency Planning Authority	a
LU	London Underground	a
MTBF	Mean Time Between Failures	a
MTTR	Mean Time To Repair	a
NDT	Non Destructive Testing	a
PM	Plant and Machinery	a
RCD	Residual Current Device	a
UKAS	United Kingdom Accreditation Service	a

7.3 Definitions

The following topic specific definitions are created:

- a) within London Underground's Glossary of Terms (S1622);
- b) from published sources that are clearly identified.

Term	Definition	Source
Castell Key	A proprietary, key operated, mechanical interlock, with a unique, embossed alpha-numeric, that ensures, the power cannot be turned on to the escalator, when the key is removed.	a
Castell lock	The proprietary key, with a unique, recessed alpha-numeric, that operates a Castell lock.	a
Diamond	The diamond shaped emergency stop device for the use of passengers.	a
Floor plate	A removable steel plate covering area from comb plate and end of the truss, between adjacent escalator trusses and between escalator truss and adjacent structural floor, finished with a hard wearing floor material.	a
Floor tray	A removable steel tray beyond escalator trusses, infilled with concrete or ribbed aluminium and finished with a hard wearing floor material.	a
Half Diamond	The half diamond shaped emergency stop device for the use of passengers.	a
HD Metro Escalator	A Heavy Duty Metro type of escalator with the drive machinery of the machine inside the truss but outside the step band.	a
LU HD Escalator	A London Underground Heavy Duty type of escalator with the drive machinery of the machine outside the truss on a separate machine plinth and designed for a heavier duty use.	a



Term	Definition	Source
Supplier	Supplier to London Underground, the primary organisation or individual that is selected to deliver a product, service or facility to London Underground and contracting directly to London Underground. This includes Consultants, Contractors, Infracos and PFI Contractors and excludes organisations or individuals selected by and contracting directly to them.	a
Truss	The steel framework that encompasses and supports the escalator step band and main drive.	a

7.4 Person accountable for the document

Person accountable for the document

Kevin Seaborne - The Head of Technical Discipline - L&E (Lifts and Escalators)

7.5 Document history

Issue no	Date	Changes	Author
R1	February 2009	Standard issued for comment	-
R2	March 2009	Updated to incorporate comments from standards manager & power engineering comments	-
R3	March 2009	Updated following internal review	-
R4	April 2009	Updated following internal review	-
R5	April 2009	Updated following internal L&E review	-
A1	April 2009	Authorised for use	-
R6	November 2009	Updated following PSC S1-01262 process	-
A2	November 2009	Authorised for use	-



Issue no	Date	Changes	Author
A3	August 2013	As per DRACCT No. 01568, attachment 8, Clause 4.1.4 updated to include clarification of F45 timescales (incorporating LU-WN-01155 Form 45 Safety Inspections). Attachment 9 clause 13.1 a, updated to reflect current organisation (incorporating Written Notice LU-WN-01156 Movement of Materials). Clauses 3.5.5, Attachment 7 clause 4.12.2 and 4.13.1, Attachment 8 clause 4.2.5, and 4.3 f & l, updated as solid retractable barriers no longer installed (incorporating Written Notice LU-WN-01157A LU-WN-01157B, LU-WN-01157C Escalator Barriers). LU-WN-01168 regarding EMC, Clause 3.11.3. revised to include appropriate references to EMC Standard S1222 and revised harmonic requirements. Attachment 6 deleted as now superseded by S1222, remaining attachments renumbered accordingly. Attachment 9 after clause 4.1b) better reflects the control of large items transported on escalators. Cross reference to 1-092 updated to S1092.	A P Miller
A4	March 2015	As per DRACCT No 02885 , The following clauses/sub-sections within the main body text are revised/added: Body text: 3.1.5.5; 3.1.5.6; 3.1.5.7; 3.1.5.8; 3.1.7; 3.2.5.2.2; 3.2.5.3 (use of an instrumented step, to record tracking alignment); 3.3.2.1.1; 3.12.2.6, 7.1.3. The following clauses/sub-sections within the Attachments are revised/added: Attachment 2: (intro); 5.1; 6.1. Attachments 3, 4 and 5 – are re-written to reflect the adoption of one-piece, die-cast aluminium steps and inclusion of the requirements of Written Notice LU-WN-01226. Attachment 9: 6.5; 11.3 and 11.4 (preclusion, relating to movement of materials and the installation of scaffolding, has been rescinded); 13.4.	A P Miller
A5	August 2015	As per DRACCT 03764, A suitability licenced member of the LU staff will be responsible for removing the asset from, and returning the asset to, service. Movement of Materials application shall identify whether Movement of Materials activity is to take place in, or out of, traffic hours.	N Gibbons
A6	January 2016	Substantial review of the standard including Attachment 1 and deletion of Attachment 11. No changes to Attachment 2 to 10. As per DRACCT 02909.	K Patel



8 Attachments

8.1 Attachment 1- Building interfaces (normative)

Contents

- 1 General
- 2 Free space for users
- 3 Atrium style escalators
- 4 Machinery spaces

1 General

- 1.1 The access to upper and lower machine chambers shall be via a full height door and a staircase, which provides direct access to these areas.
- 1.2 Machine chamber floors and incline shall have 1 in 75 fall towards the drainage channels.
- 1.3 Drainage channels shall be provided in upper and lower machine chambers and on the incline. The drainage channels shall be connected to a sump in lower machine chamber.
- 1.4 The lighting in the machine chambers shall comply with LU Standard S1066 Lighting of London Underground Assets. The lighting of the upper and lower machine chambers and on the incline shall prevent the stroboscopic effect of moving machinery such that maintenance staff can recognize the true linear and rotational movement of components.
- 1.5 Provision shall be made for any equipment and services associated with the escalator installation as well as reasonably foreseeable future services so as to ensure that the minimum clearances specified are not encroached on. The services and equipment shall include but not be limited to:
 - a) Control and monitoring equipment;
 - b) Switching and isolation equipment;
 - c) Wiring and cable trays;
 - d) Fire detection and suppression equipment;
 - e) Piping;
 - f) Ventilation equipment;
 - g) 32A TP&N 400V socket outlet, with 30mA RCD protection and IP65 rated, in upper and lower machine chambers;
 - h) Oil and grease storage bunker.
- 1.6 The temperature in the machine chambers shall be maintained within the operating range of the equipment and wherever personnel are required to enter or work in this environment measures shall be taken to comply with the Workplace (Health, Safety and Welfare) Regulations.
- 1.7 The noise limit in the machine chamber shall not exceed a maximum of 80 db(A).
- 1.8 Storage shall be provided for passenger side guarding (see clause 3.13.1.1.1) on the concourse of the upper and the lower landings close to escalator.



Attachment 1- Building interfaces (normative)

- 1.9 The machine chambers shall be used only for accommodating equipment necessary for the operation, maintenance and inspection of the escalator.

2 Free space for users

- 2.1 The horizontal distance between the outer edge of the escalator handrail and any fixed part of the escalator or station fabric shall not be less than 150mm, except for the clearance between the outer face of the handrail and the inner face of the newel boxes. This shall be not less than 80mm.

3 Atrium Style Escalators

- 3.1 Atrium style escalators shall have a minimum clear headroom as stated in LU Standard S1371 Station Planning, clause 3.10.5.1.
- 3.2 On 'Atrium' style escalators the risk of preventing people and objects falling into the atrium shall be mitigated. The design of the mitigation shall be approved by LU.

4 Machinery spaces

4.1 Escalator envelope

- 4.1.1 The escalator envelope shall be constructed with upper, incline and lower machine chambers. The dimensional requirements are defined in figures 1, 2 and 3.