

Category 1 Standard

S1157 Track – Performance, Design and Configuration

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1 Purpose

The purpose of this standard is to identify the performance, design and configuration requirements for new track components, configurations, layouts and track bed.

2 Scope

2.1 The standard covers:

- a) principles for new designs of track components and configurations;
- b) design of layouts;
- c) requirements for the use of current standard designs of track components and configurations;
- d) requirements for the following track support features: ballast, shingle, formation, sand blankets (and equivalents), geosynthetics, second-stage concrete, transition slabs and drainage systems.

2.2 The requirements in this standard apply to the upgrading and renewal of existing track only to the extent reasonably practicable.

2.3 Where it is mandatory that any of the supporting information in Section 5 of this standard is to be applied, the appropriate requirement is set in Section 3.

3 Requirements

3.1 Performance

3.1.1 The track system and components shall be designed to maximise safety and reliability while minimising whole-life costs. They shall be compatible with:

- a) operational, rolling stock, power, civils and signalling requirements;
- b) existing infrastructure and assets;
- c) applicable climatic and ambient (e.g. dust) conditions;
- d) track design rules;
- e) rail stressing rules;

Additionally they shall:

- f) be fail safe or give early warning of failure where reasonably practicable;
- g) be maintenance-free (as far as reasonably practicable) or facilitate ease of inspection, maintenance and cleaning;
- h) comply with LU fire safety requirements as prescribed in standard 1-085;
- i) be corrosion-free or function effectively taking into account corrosion without adversely affecting other components;
- j) be such that individual components:
 - I. are easy to repair or replace;
 - II. can be clearly differentiated from other and similar components, avoiding incorrect assembly or interchange that results in an unsafe condition;
 - III. give, where reasonably practicable, the date of manufacture and the manufacturer;
 - IV. cater for the risk of derailment and the need to provide for derailment containment (e.g. where track is alongside columns supporting structures);
 - V. cater for standardisation wherever reasonably practicable;



VI. minimise the need for speed restrictions, throughout the life of the track.

- 3.1.2 Track system and component design shall consider the normal track loading generated by speed and tonnage of both service vehicles and engineer's vehicles using any particular route. As a minimum, designers should take into account:
- a) minimum annual load cycles of 2.4 million 12-tonne axles at 120km/h (nominally configured as 2m between bogie axles and 10m between bogie centres) and 1.4 million 17-tonne axles at 80km/h;
 - b) the varying track conditions according to track category set out in standard S1159;
 - c) maximum operating speeds of 120km/h for passenger trains and 80km/h for engineer's trains or on-track plant.
- 3.1.3 Track components shall be designed to cater for new and worn wheel profiles. The minimum allowable wheel diameter is 650mm, with 330mm permitted for certain Engineer's plant at low speeds.
- 3.1.4 The design of track components shall allow for the range of unsprung mass of passenger and engineer's trains on LU and the dynamic loading from this mass.
- 3.1.5 Track components shall be designed to function on horizontal curves with a radius of 60m measured nominally from the inner running rail.
- 3.1.6 Track components shall be designed to function in curved track with a cant of up to 180mm.
- 3.1.7 Track components shall be designed to function in curved track with a cant deficiency of up to 180mm.
- 3.1.8 Track components shall be designed to function in track with a gradient of 1 in 25.
- 3.1.9 Track components shall be designed to function through:
- a) an ambient dry-bulb temperature range of -15C to +35C;
 - b) adverse weather including snow, ice and rain;
 - c) a rail temperature range of -15C to +53C;
 - d) relative humidity extremes of 25% to 99%;
 - e) maximum rainfall that is typically not more than 38mm per day;
 - f) summer conditions of clear skies with no local shade when solar intensity of 750-800W/m² is typical;
 - g) a tube tunnel temperature range of 20C to 30C throughout the year. In other tunnels the temperature range will be wider, tending towards ambient at openings;
 - h) tube tunnel relative humidity extremes of 35% to 65%.
- 3.1.10 The design of track components shall consider potential failure modes and the consequences if other track components in the near vicinity fail.
- 3.1.11 All components and configurations used in the track shall be subject to product approval and recording in the Approved Products Register. The Register references or contains drawings and other relevant documentation, and any conditions applicable to the use of the item.
- 3.1.12 The permanent way system shall, as far as reasonably practicable, incorporate standardised material types, products and configurations in order to simplify installation, inspection and maintenance procedures.



- 3.1.13 Where non-standard or novel materials, products, configurations or processes are proposed, any safety risks arising (e.g. at physical interfaces or from lack of staff familiarity) shall be managed ALARP.
- 3.1.14 Materials, components and certain processes shall comply with the standards listed in Attachment 2.

3.2 Design principles

Notes: The requirements in this section relate to all lines. However, certain exceptions are permitted for depots and sidings: see clauses 3.2.2.8 and 3.2.7.3.

Where track work is carried out in existing tunnels, or where other constraints are unavoidable, the design values set out in this section shall be achieved to the extent reasonably practicable.

3.2.1 General

- 3.2.1.1 Track alignments shall be designed such that the space between tracks and the clearances to structures adjacent to tracks accords with the gauging and clearance requirements in standard S1156.
- 3.2.1.2 Within defined mathematical rules and limitations, as set out in Attachment 1, the track design of horizontal and vertical curves, and the transitions between them, shall as far as reasonably practicable:
- a) follow the design principles of EN 13803;
 - b) provide an acceptably low risk of derailment: this may be demonstrated using an accepted and validated track-train dynamics model at locations where safety cannot otherwise be demonstrated;
 - c) maximise the speed of trains in an economic and efficient manner;
 - d) minimise the need for maintenance to track and trains;
 - e) maximise the ease of maintenance;
 - f) provide optimised vehicle/platform/people interface in line with requirements.
- 3.2.1.3 The track design shall optimise safety and performance with respect to:
- a) the layout;
 - b) the track system and components;
 - c) ease of construction, future maintenance, renewal and disposal;
 - d) the reduction or elimination of the need for speed, or other, restrictions;
 - e) operational requirements;
 - f) potential failures;
 - g) Railway Safety Principles and Guidance (Office of Rail and Road).
- 3.2.1.4 Track layouts shall be designed having regard to the following factors:
- a) service frequency;
 - b) service operational moves;
 - c) train headways;
 - d) train lengths;
 - e) signalling requirements;
 - f) train speeds in the layout area, which are dependent on:
 - I) train acceleration and deceleration characteristics;
 - II) track gradients;
 - III) location of existing and proposed permanent speed restrictions;
 - IV) location of stopping places or station platforms or both;



- g) practicality of construction and maintenance;
- h) site space constraints.
- i) where relevant, places of safety.

3.2.1.5 Systems risk must be considered, and wheel/rail contact behaviour may be adversely affected by changes to track configuration or rail profile (especially at switches). All such changes with the potential to have an adverse effect shall be subject to appropriate analysis, which may include modelling, to demonstrate compatibility and low risk of derailment with rolling stock approved to run over that route.

3.2.2 Horizontal alignment of plain line

3.2.2.1 The horizontal alignment shall consist of straight track, and circular curved track of the largest possible radius. Connections between circular curves, and between circular curves and straights, shall be by transition curves (but see 3.2.2.8 regarding depots and sidings).

3.2.2.2 The design of horizontal curves, including elements such as transition curve lengths, cants and cant gradients, shall take account of the speeds of trains on a particular curve or portion of a curve.

3.2.2.3 The geometric design of curves shall conform with Table 1. The data shown are those for new work and apply to the upgrading and renewal of existing tracks only to the extent reasonably practicable. They should also be used wherever practicable during maintenance works.

Table 1 - Curves: requirements for geometric design		
Parameter	Desirable minimum	Absolute minimum
On running lines		
Length of straight track or circular curve	45m	25m
Curve radius		
- where line speed exceeds 80km/h	500m	
- elsewhere	400m	250m
- through station platforms	straight	1000m
In depots		
Curve radius		
- if only used by LU rolling stock	201m	120m
- elsewhere	201m	140m
Distance between tangent points		12m

3.2.2.4 Track through station platforms shall where practicable be straight. Where straight track throughout is not practicable the following shall be used in order of preference:

- a) up to 25m at each end of the platform may be curved, in either direction, to a radius not less than 1000m;
- b) the entire platform may be curved to a radius not less than 1000m where the platform edge is convex., i.e. where the driver of the train can see along the full length of the platform edge when the train is stationary in the platform.

3.2.2.5 Transition curves shall be provided wherever possible. They shall be of cubic parabola or clothoid form, which for all practical purposes give a constant rate of change of curvature along the transition.



- 3.2.2.6 Where two consecutive curves in the same direction would be separated by less than 25m of straight track, the two curves shall be separated by a transition curve.
- 3.2.2.7 Where two consecutive curves in opposite directions would be separated by less than 25m of straight track, the two curves shall be separated by transitions on each curve, meeting each other tangentially. Reverse transition curves shall be designed to give a constant rate of change of curvature and cant.
- 3.2.2.8 Tracks in depots and sidings need not incorporate transition curves.

3.2.3 Virtual transitions

Virtual transitions may be used to assess speed limits at geometry changes where no geometric transition exists. The virtual transition shall be restricted to a length of 10.06m, except in the case of Train Operating Company (TOC) trains. These may have the speed limit assessed using a longer virtual transition equal to the larger bogie spacing up to a maximum of 12.2m, in accordance with Network Rail policy, subject to:

- a) in junctionwork, a derailment assessment being carried out using an LU-approved method, if the virtual transition length is greater than 10.06m and where the switch is not an approved curved planed flat bottom design. The derailment assessment shall show a derailment speed above the calculated speed limit by a suitable safety margin;
- b) any differential speed limits being signed appropriately;
- c) measures being taken to prevent the TOC from applying the higher speed to trains with bogie spacing shorter than that assumed in the assessment.

Note: 10.06m is approximately the shortest distance between bogie centres on LU passenger cars.

3.2.4 Vertical alignment of plain line - general

- 3.2.4.1 The vertical alignment shall consist of constant gradients connected by vertical curves.
- 3.2.4.2 Resistance to lateral movement on curves comprising welded track shall be maintained by limiting the variation in track level between tracks, as follows:
- a) where a standard ballast shoulder **is not** provided to the six-foot end of the higher sleeper, the non-coplanarity between the sleeper ends across a 1970mm six-foot shall be limited to 75mm, plus 12mm for each 100mm increase above 1970mm;
 - b) where a standard ballast shoulder **is** provided to the six-foot end of the higher sleeper, the maximum non-coplanarity between the sleeper ends across the six-foot shall be that calculated by assuming a ballast slope of 1-in-2 from the toe of that shoulder to the lower sleeper end.

3.2.5 Vertical alignment of plain line - gradients

- 3.2.5.1 The length of track between vertical tangent points, except for hump profiles, shall be as follows:
- a) as short as possible for gradients steeper than 1% (1 in 100);
 - b) absolute minimum of 25m for any gradient.
- 3.2.5.2 The limits on gradient, except for hump profiles, shall be:
- a) maximum - desirable 1.25% (1 in 80);
 - b) maximum - absolute 2% (1 in 50);



- c) minimum in tube - desirable 0.5% (1 in 200);
- d) minimum in tube - absolute 0.25% (1 in 400);
- e) through station platforms - desirable - level;
- f) through station platforms - maximum - absolute 0.2% (1 in 500). Vertical intersection points may be located at the ends of platforms;
- g) at locations designated for intermediate emergency detrainment the maximum gradient shall be 0.2% (1 in 500).

3.2.5.3 If the longitudinal profile so permits, gradients up to and down from stations (i.e. hump profiles) shall be provided as follows:

- a) gradient absolute maximum 2.86% (1 in 35);
- b) length – desirable minimum 200m.

3.2.5.4 In depot tracks and sidings (open and sub-surface), gradients shall be as follows:

- a) desirable - level;
- b) maximum - absolute 0.38% (1 in 260).

3.2.5.5 Gradients of tube tunnel sidings shall be as follows:

- a) maximum - 0.38% (1 in 260);
- b) minimum - 0.25% (1 in 400).

3.2.5.6 Tube sidings shall fall away from running lines. Other sidings shall desirably not fall towards running lines.

3.2.6 Vertical alignment of plain line - curves

3.2.6.1 The design of vertical curves shall take account of the speed of trains on the vertical curve. This shall depend on the following:

- a) line speed;
- b) passenger stock speed characteristics in service including acceleration and deceleration;
- c) location of adjacent stations;
- d) gradients;
- e) signalling and headway constraints;
- f) clearances.

3.2.6.2 Vertical curves shall be equally disposed horizontally about the vertical intersection points and shall ideally be of a parabolic or circular form.

3.2.6.3 The vertical acceleration limits shall be:

- a) desirable maximum: 0.1m/s^2 ;
- b) except as shown in (c) below, absolute maximum: 0.3m/s^2 ;
- c) where an existing vertical radius is below 1600m an absolute maximum of 0.6m/s^2 is permitted as a basis for calculating train speed, subject to:
 - I. the calculated train speed then being reduced by not less than 5km/h;
 - II. the use of this acceleration value being justified by avoidance of a local speed restriction;
 - III. the track condition being within the maintenance target (MT) as defined in standard S1159.

3.2.6.4 Vertical curve instantaneous radii shall be:

- a) running lines - desirable minimum - 3200m;
- b) running lines - absolute minimum - 1600m;



- c) preferably not more than 20,000m;
- d) depot tracks and sidings - absolute minimum - 500m.

3.2.6.5 In ballasted track, if the difference between designed grades is less than 0.15% (e.g. between 0.20% and 0.35%) a vertical curve design is not required.

3.2.7 Cant and cant deficiency

Note: Cant is applied on curves by raising the outside running rail above the level of the inner running rail. The level of the top of the lower running rail is used as a datum.

3.2.7.1 Cant shall be applied as follows:

- a) no cant on straight track;
- b) constant cant on circular curves, unless speed is varying (e.g. on approach to or exit from stations) in which case cant may be ramped in order that cant deficiency and its rate of change may be held within acceptable limits;
- c) uniform rate of change of cant on transition curves.

3.2.7.2 In order to optimise conditions at the wheel-rail interface, the applied cant shall where reasonably practicable be less than the equilibrium value calculated at normal operating speeds, even for the slowest part of the train, provided the criteria in the following clauses are met.

3.2.7.3 Depot tracks and sidings shall be laid without cant.

3.2.7.4 Cant and cant deficiency limiting values for running lines are shown in Table 2.

**Table 2 – Cant and cant deficiency – limiting values**

Parameter	Desirable	Absolute	Note
Maximum allowable applied cant (mm)			
Plain line	125	150	
Station platforms	zero	110	
Switches and common crossings (on through line)		80	
Obtuse crossings		65	
Maximum allowable negative (adverse) cant (mm)			
Through switches and common crossings		80	
Through obtuse crossings		65	
Maximum allowable cant deficiency (mm)			
Plain line, open and sub-surface jointed track and LWR (ballasted)	50mm	90 (100)	6
Plain line BH CWR	50mm	90 (100)	1, 6
Plain line FB CWR	50mm	90 (110)	6
		110 (150)	5, 6
Junctionwork (BH, main route, including tips)		90	
Junctionwork (BH, turnout route, including tips)		90	
Junctionwork (FB, main route, excluding tips)		90 (110)	6
		110 (150)	5, 6
Junctionwork (FB, turnout route, excluding tips)		90 (110)	6
Concreted track (E = actual cant)		90 - E/4	3
Maximum allowable cant gradient			4
Ballasted track		1 in 400	
Concreted track		1 in 300	
Maximum allowable rate of change of cant (mm/sec)			
Plain line	35	55	
Junctionwork (vertical FB design, excluding tips)	nil	80	
Junctionwork (vertical FB design, at tips)	nil	ignore	
Junctionwork (BH, main route, including tips)	nil	55	
Junctionwork (BH, turnout route, including tips)	nil	55	2
Maximum allowable rate of change of cant deficiency (mm/sec)			
Plain line	35	55 (70)	6
Junctionwork (vertical FB design, excluding tips)	35	80 (85)	6
Junctionwork (vertical FB design, at tips)	ignore	ignore	
Junctionwork (bull head, including tips)	35	55	2

Notes:

- 1) This figure to be used only where the CWR comprises flat-bottom rail on concrete sleepers.
- 2) At the switch tips, the effective radius shall be obtained by calculating the offset at the tip, based on a chord equal in length to the virtual transition (see clause 3.2.3).
- 3) In tube sections of track, the maximum cant deficiency shall be as shown below:

Bakerloo line (72 Tube Stock)	90 – E/4 mm
Central line (92 Tube Stock):	90mm
Jubilee line (96 Tube Stock)	90mm
Northern line (95 Tube Stock):	90mm
Piccadilly line (73 Tube Stock)	90 – E/4 mm
Victoria line (09 Tube Stock):	90mm
W'loo & City line (92 Tube Stock)	90mm

For rolling stock not shown above, which will travel at full line speed, for example track recording vehicles and pilot cars, running at 90mm cant deficiency shall depend on it being shown, e.g. through sway calculations, that the stock would not infringe the kinematic limit under all conditions specified in LU standards.



- | | |
|----|---|
| 4) | Where a cant gradient is provided, it is recommended that its gradient be not less than 1 in 1000, and preferably not less than 1 in 700. |
| 5) | Value can be used providing clearances are sufficient to allow the kinematic limit to be exceeded. |
| 6) | Value shown in brackets is applicable only for the “fault condition” speed reached by a vehicle when the automatic train protection has been activated. |

Note:	Where contrary flexure turnouts occur on curved track with cant, the turnout track is necessarily canted in the wrong direction, which is referred to as 'negative cant'.
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3.2.8 Locational references of new horizontal and vertical alignment designs

3.2.8.1 Horizontal alignment designs shall be referenced to the LU survey grid (which is itself based on the Ordnance Survey grid). Grid references shall be determined for:

- a) intersection points of straights;
- b) theoretical tangent points of curves;
- c) origins of curve radii;
- d) ends of transitions;
- e) every 100m on straights over 200m long.

3.2.8.2 Vertical alignments shall be referenced to Newlyn datum (or 100m below Newlyn datum in tunnels).

3.2.8.3 Grid and level references shall be determined for

- a) intersection points of gradients;
- b) vertical tangent points.

3.3 Construction

3.3.1 Track elements and components shall be configured where possible to present a continuous running surface by the avoidance of discontinuities, minimise speed restrictions and maximise safety to railway personnel and the public during:

- a) installation;
- b) normal operation;
- c) maintenance;
- d) renewal;
- e) disposal or any other foreseeable operation.

3.3.2 Datum markers (type 7-01408-030 or 7-01408-035 in standard S1004, or equivalent), indicating cant, radius, offset and rail level, shall be installed as a minimum as follows in order to preserve clearances:

- a) in tunnel sections and where any continuous lineside structure is within 1.5m of the nearest rail:
 - I. at 20m intervals on straights and curves greater than 750m radius and associated transitions;
 - II. at 10m intervals on curves between 200m and 750m radius and associated transitions;
 - III. at 5m intervals on curves less than 200m radius and associated transitions;
- b) through station platforms – at 5m intervals.



- 3.3.3 Datum markers shall also be installed at individual structures within 2m of the nearest rail (e.g. bridge supports) and any location where they may assist in preserving the design geometry.
- 3.3.4 Track geometry transition plates (type 7-01408-040 in standard S1004) shall be fixed at each end of horizontal transition curves, pointing into the transition curve. Each plate shall be completed with the relevant geometry information.
- 3.3.5 Where there are physical restrictions on tamping and lining of the track, the track shall be marked with appropriately-worded plates attached to the top of the nearest sleeper end.
- 3.3.6 Sleepers and bearers shall not come into contact with tunnel linings.
- 3.3.7 The area of the cess within a notional line 2m from the nearest rail shall:
- be suitably finished to provide an even surface for walking;
 - provide a minimum width of 800mm;
 - be maintained, as far as reasonably practicable, clear of refuse, debris, litter and unwanted vegetation;
 - not obstruct free drainage of the track system;
- 3.3.8 The following items shall be marked in white in order to minimise tripping hazards:
- ends of check rails;
 - ends of rails temporarily stored in the four-foot (except in tube station grounds);
 - cross-track cabling;
 - track-mounted lubricators;
 - survey pegs;
 - any other items identified as hazards by local site safety assessment.

3.4 Plain line configuration

Note: In this and subsequent sections of this standard, 113A flat-bottom rail is referred to as “56E1”, in keeping with EN 13674-1.

- 3.4.1 The nominal track gauge in plain line shall be 1435mm, subject to the tolerances and variations shown in standard S1159. However, where a depot pit road is used solely for rolling stock gauging purposes the gauge shall be 1428mm.
- 3.4.2 Rail for new work and major renewal shall be
- CWR, except where this standard dictates the use of short rails;
 - 56E1, or other flat-bottom profile approved by LU Head of Track Engineering;
 - of a grade as described in section 3.6.

Note: 56E1 is currently the only symmetrical FB profile approved for use. Alternative profiles may be accepted in the future where there is economic justification. Such profiles may then be used, subject to any conditions shown in the Approved Products Register.

- 3.4.3 In Open and Sub-surface sections, forms of ballastless track in which sleepers are replaced by or are located in in-situ concrete are acceptable in principle. They shall provide for the correct rail inclination and track gauge, and for drainage. The concrete shall provide support and clearance for any necessary signalling, telecoms or power equipment or cable runs and offer a suitable walking surface. Use of such track shall be subject to site-specific approval by LU Head of Track Engineering.



- 3.4.4 If ballastless track is not proposed, track configuration for new work and major renewal in Open and Sub-surface section running lines and associated depots and sidings shall comprise concrete sleepers fitted with under-sleeper pads complying with T0441, ballast, and drainage where required. If a concrete sleeper appropriate to the track configuration is not feasibly available, or if a transition from concrete sleepers to softwood sleepers is required, sleepers of hardwood, or of composite material approved by LU Head of Track Engineering, may be used.
- 3.4.5 In Tube section running tunnels, track forms without sleepers are preferred. They shall provide for the correct rail inclination and track gauge, and for drainage. The concrete shall provide support and clearance for any necessary signalling, telecoms or power equipment or cable runs and offer a suitable walking surface. Where a drainage channel is provided in the four-foot the walking surface may comprise a fire-resistant cover approved as suitable for forming a non-slip walking surface, secured where necessary to resist uplift during the passage of trains.
- 3.4.6 Track configuration for new work and major renewal in Tube section station grounds shall be as follows:
- a) resilient baseplates, without pit-blocks (temporary wood pit sleepers may be installed on a 1 in 4 basis during conversion in order to maintain correct track gauge and rail inclination);
 - b) positive conductor rail blocks;
 - c) negative conductor rail pedestals and pedestal caps;
 - d) paper traps.
- 3.4.7 Track configurations shall include compatible rail pads and rail fastening assemblies, and baseplates, screwspikes and ferrules if required.
- 3.4.8 Other than for localised replacement, any proposed use of bullhead components is subject to site-specific approval by LU Head of Track Engineering.

3.5 Junctionwork configuration

3.5.1 General

- 3.5.1.1 Switches and crossings shall provide a safe, controlled means for traffic to move from one track to another whilst:
- a) optimising ride quality;
 - b) minimising speed restrictions;
 - c) minimising side and head wear.
- 3.5.1.2 New junctionwork shall use 56E1 FB stock rails and compatible switch rails and conform to the principles of EN 13232. Bearers shall preferably be concrete, the specific types being selected (according to whether the rails are mounted directly or on baseplates) so as to provide a uniform soffit level within 10mm.

Note: FB junctionwork to Network Rail's "RE/PW" designs has been used by LU in two vertical forms: "full depth" (56E1 stock rails and 56E1 switch rails) and "shallow-depth" (56E1 stock rails and 54E1A1 switch rails). These designs are deemed to conform to EN 13232. This EN requires the customer to specify a minimum heel flangeway, which LU does at 50mm (clause 3.5.2.4). However, neither design is consistently compliant with that requirement. Proprietary designs, modified from RE/PW, are now available with compliant flangeways: these are shown in the Approved Products Register and are preferred when installing new or replacement FB junctionwork.

- 3.5.1.3 Where renewal of junctionwork in depots and sidings with FB rail is not economically viable, it is permitted to use 95 BH.



- 3.5.1.4 See section 3.6 for rail grade selection.
- 3.5.1.5 Compatible components shall be used for maintenance and partial renewal of BH junctionwork in running lines until full replacement in FB rail of the particular layout takes place.
- 3.5.1.6 When a layout incorporates abutting junctionwork units, standard running line stock rail fronts and crossing leg lengths shall be provided where practicable. They shall be shortened only if there is an overall advantage to the design, in which case stock rails with standard depot short fronts shall be used.
- 3.5.1.7 Non-insulated joints within junctionwork shall be welded, or, if this is not reasonably practicable, tight-joint fishplates shall be used.
- 3.5.1.8 Cast or fabricated components shall be marked to identify their type and aid traceability.
- 3.5.1.9 Transitions, by means of twist rails, from vertical rail in junctionwork to 1 in 20 inclined rail in plain line shall:
- a) not affect safety or ride quality;
 - b) be located clear of junctionwork, where practicable not in standard stock fronts or crossing legs;
 - c) be minimised in number: plain line track between units of vertical FB junctionwork shall use vertical rail up to a distance of 36.6m; such lengths of vertical plain line shall be formed with concrete sleepers if either of the abutting items of junctionwork is on concrete bearers;
 - d) be in the same bed;
 - e) be such that the twist is not closer than 1420mm to any welded or plated joint in the same rail.
- 3.5.1.10 Where the design and configuration permits, and adjacent track is stressed CWR, junctionwork shall preferably be stressed and connected to the adjacent CWR without expansion switches. Recommended procedures for stressing junctionwork are given in Network Rail standard NR/SP/TRK/3011.

3.5.2 Switch panels

- 3.5.2.1 Machining of switches to a chamfered profile is preferred for BH switches and obligatory for FB switches. In both cases the machining shall be in accordance with approved drawings.
- 3.5.2.2 Switch and stock rails shall be manufactured and installed as matching pairs.
- 3.5.2.3 When in the closed position, with the stock rail to the correct alignment, the switch rail shall bear evenly against the stock rail throughout the length of the head planing and against the distance blocks: on-site crowing is permitted in order to achieve this. In order to ensure satisfactory operation of the switch, the switch rail should be stress-free in the half-open position, with no bias towards either the closed or open positions. Any rolling (branding) marks shall be removed from the webs of the rails in order to ensure correct fit of distance and ball-and-claw units or heel blocks.
- 3.5.2.4 When the switch rail is the open position, the clearance between the switch and stock rails shall nowhere be less than 50mm.

Note 1: Where the achievable clearance (after adjustment of stretcher bar(s) if necessary) is between 42mm and 50mm, it is permitted to apply, in the workshop, up to 8mm of snipe cut to the back of the switch blade, subject to site-specific approval by the LU Head of Track Engineering;



Note 2: Clearances greater than 50mm are desirable. These are achievable with extended switch rail flexing lengths and/or, subject to acceptance, actuators with wider toe openings.

- 3.5.2.5 A 45-degree chamfer, maximum 3mm x 3mm, shall be applied to machined edges at the foot of switch rails and stock rails.
- 3.5.2.6 Manufacturing processes including heating, cooling, bending and machining shall be carried out in a manner which does not damage the component or adversely affect its intended use and operating performance.
- 3.5.2.7 The standard length of stock rail fronts shall be:
- a) 3070mm for FB switches;
 - b) 3050mm for BH switches in running lines;
 - c) 1650mm for BH switches in depots and sidings;
 - d) 1650mm for running lines where site constraints dictate.
- 3.5.2.8 Switch protectors shall not be used on running lines.
- 3.5.2.9 Where switch rollers (of an approved type for the type of switch concerned) are used the lift imparted by the rollers shall not exceed 1.5mm at the switch toes and 3mm at any supplementary drive position. The gap between the kicking strap on the first stretcher bar and the underside of each stock rail shall not be less than 3mm. The lifts and the resulting gaps above the kicking strap and at each slide plate, at installation and any subsequent adjustment, shall be recorded on the form in Attachment 3.

Note: It is good practice for switches to be ground approximately 8 to 12 weeks after installation to remove any lipping, to re-establish the correct running surface profile.

3.5.3 Crossings

- 3.5.3.1 FB crossing angles shall, where practicable, be selected from those used by Network Rail as shown on RE/PW drawings. However, it is permitted to use other angles where this is dictated by site constraints. BH crossings shall normally be used only for like-for-like replacements..
- 3.5.3.2 The preferred use of the various types of crossing is shown in Table 3:

Table 3 – Use of various types of crossing	
Annual line tonnage (MGT)	Type of crossing
≥15	Cast monobloc or cast centre
<15	Cast monobloc, cast centre or semi-welded
In running lines, fabricated crossings shall be installed only as like-for-like maintenance replacements, and then only if it is not reasonably practicable to use a cast or semi-welded crossing	

- 3.5.3.3 Movable angles (switch diamonds) shall be used instead of fixed obtuse crossings, according to the radius of the track across the diamond, as shown in Table 4:

Table 4 - Criteria for using movable angles	
Radius of track across diamond (m)	Moveable angles to be used for crossings flatter (more acute) than
360 or above	1 in 7.5
between 160 and 360	1 in 7
between 120 and 160	1 in 6.5
between 80 and 120	1 in 6



- 3.5.3.4 The point rail in a fabricated crossing shall be on the more heavily used side of the crossing. If both sides of the crossing are equally used the point rail shall be on the more sharply curved side of the crossing.
- 3.5.3.5 Cast crossings shall be inspected and ground after installation to remove any lipping and to re-establish the correct running surface profile, as shown in Table 5:

Table 5 – Post-installation grinding of cast crossings	
Cumulative passing traffic tonnage since installation (MGT)	Action
Between 3 and 5	Initial mandatory grind
Between 10 and 12	Detailed inspection and, if batter or lipping are present, grind to correct
Between 20 and 24	

3.5.4 Location

- 3.5.4.1 Junctionwork shall be located outside station grounds, with switch toes positioned in accordance with signalling requirements.
- 3.5.4.2 Junctionwork shall wherever practicable be sited on straight track. Where this is not practicable, the location shall be a circular curve of as large a radius as possible; however, if a radius of 400m or less is unavoidable the particular requirements of clause 3.5.5 shall be followed.
- 3.5.4.3 Switches shall not be located on vertical curves.

3.5.5 Switches in facing turnouts approached by curves of radius 400m or less

- 3.5.5.1 There is a heightened risk of derailment when a wheel in flange contact with the outer rail of an approach curve encounters a switch entry angle. This may occur when the turnout has the same direction of curvature as the approach curve. Switches approached in facing mode by curved track shall therefore, where practicable, be handed opposite to the handing of the approach curve if all of the following apply:
- the location is on the running line or where a derailment could represent a safety risk to a running line;
 - the switches are ever used for facing moves;
 - the 20m of track immediately approaching the switch contains a radius of 400m or less.
- 3.5.5.2 If, in the circumstances defined above, the direction of curvature of the turnout is the same as the approach curve the switch shall be classified as a “Controlled Switch” and shall be subject to the specific controls set out in standard S1158.

3.5.6 Trap points

Trap points shall be installed in the following situations:

- in sidings, sited so as to divert unauthorised movements away from running lines;
- in running lines which are used to stable rolling stock where the gradient exceeds 1 in 260. They shall be sited to prevent potential runaway vehicles from obstructing the running line approach to the stabling area.



3.6 Running rails

3.6.1 General

New rail shall comply with T0442.

3.6.2 Rail grades

3.6.2.1 Except as shown in clause 3.6.2.2, rail grades (as defined in EN 13674) shall be as follows:

- a) plain line, switches, adjustment switches and expansion switches: R260;
- b) crossings: either cast austenitic manganese steel or R260;

3.6.2.2 Where grades other than those in clause 3.6.2.1 are proposed they shall be subject to prior approval by LU and shall as far as reasonably practicable be selected so as to maintain technical compatibility between wheels and rail and minimise the whole life cost of the wheel-rail system. In particular grade selection shall be such as to:

- a) minimise the occurrence of rolling contact fatigue and other rail defects;
- b) minimise the need for novel processes for machining, welding, inspection and maintenance.

3.6.3 Rail lengths

3.6.3.1 Discontinuities in installed rails shall be minimised.

3.6.3.2 The minimum length of a rail between joints and between joints and track features shall be as shown in Table 6.

Table 6 – Minimum distances (m) between features within or alongside the same rail				
		Aluminothermic weld	Flash weld in plain rail	Plated joint
Features in same rail	Aluminothermic weld	4.5	4.5	4.5
	Flash weld in plain rail	4.5	3.5	4.5
	Flash weld for leg-end	1.8 a, b	4.5	4.5 a, d
	Plated joint	4.5	4.5	4.5 e
	Forged rail transition	2.25	0.2 c	2.25
	Expansion switch	4.5 f	4.5 f	4.5 f
Features attached to or alongside rail	Deck end	3.0 g	no limit specified	3.5 h
	Joint in longitudinal bridge bearer	2.0	no limit specified	2.25
	Trainstop	i	i	3.5 j
	Manhole, catchpit	i	i	1.0 j
	Lubricator	i	i	1.0 j
	Axle counter	i	i	1.0 j, k
	Conductor rail ramp	i	i	1.0 j, l
	Steel conductor rail joint	i	i	1.0 j
	Conductor rail anchor	i	i	1.0 j
	End of check rail (parallel section)	i	i	5.0
a) A length of 1.8m must be on at least three sound supports. b) If 1.8m is not practicable the length may be reduced to not less than 0.7m. If less than 1.8m, the leg-end must be on at least one sound support and the aluminothermic weld is to be ultrasonically tested with U6 within 28 days of installation and a copy of the test record retained in the asset management system (Ellipse or Maximo) c) Refers to the flashbutt weld adjacent to the forged change of section. Distances between that weld and other features shall be as shown in this table. d) Distance may be reduced to 1.8m for an insulated joint if 4.5m cannot be achieved e) Distance may be reduced to 3.3m for a pair of insulated joints in a “10-10” assembly f) Measured along full rail section: machined part is extra.				



- g) Wherever practicable. For any shorter distance there must be at least two sound supports between the weld and the end of the deck.
- h) Insulated joints may be located on or off the deck. Non-insulated joints must be off the deck.
- i) Distance will be governed by the practicality of installing the weld (using mobile plant in the case of flashbutt). No minimum distance is specified for installing the features listed from an existing weld.
- j) Distance may be reduced for insulated joints if required by Signals Engineer
- k) A new permanent plated joint is not to be placed within 1m of an existing axle counter but a new axle counter may be placed within 1m of an existing plated joint if neither can be relocated
- l) In the case of FB junctionwork the distance for any type of plated joint may be reduced on the additional criterion of difficulty.

3.6.3.3 The maximum length of a rail shall be determined on the basis of the need to mitigate the effects of thermal forces, considering the track radius and the methods of joining the rails as shown in Table 7. In addition, in junctionwork account shall be taken of the need to minimise relative movement of stock rails and switch tips.

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