

Level 2

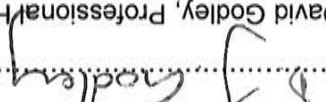
Design and construction of track

Endorsement and Authorisation

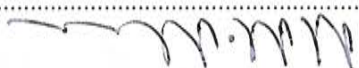
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User information

This Network Rail standard contains colour-coding according to the following Red–Amber–Green classification.

Red requirements – no variations permitted

- Red requirements are to be complied with and achieved at all times.
- Red requirements are presented in a red box.
- Red requirements are monitored for compliance.
- Non-compliances will be investigated and corrective actions enforced.

Amber requirements – variations permitted subject to approved risk analysis and mitigation

- Amber requirements are to be complied with unless an approved variation is in place.
- Amber requirements are presented with an amber sidebar.
- Amber requirements are monitored for compliance.
- Variations can only be approved through the national non-compliance process.
- Non-approved variations will be investigated and corrective actions enforced.

Green guidance – to be used unless alternative solutions are followed

- Guidance should be followed unless an alternative solution produces a better result.
- Guidance is presented with a dotted green sidebar.
- Guidance is not monitored for compliance.
- Alternative solutions should be documented to demonstrate effective control.

Colour-coding according to the Red–Amber–Green classification cannot be applied directly to a table itself. The text specifying the table will be classified and this classification applies to the entire contents of the table.

Amendment marks

- First document amendments are presented with a single black line to the right of the affected text.
- Second document amendments are presented with a double black line to the right of the affected text.

Where a requirement calls for the agreement of the RAM this shall be documented either as a specification requirement in the Project Requirement Specification (or equivalent) and/or recorded as a deviation to design standards in the Approval in Principle submission and subsequently authorised by the RAM[Track].

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Issue record

Issue	Date	Comments
1	Feb 1996	New specification.
2	Apr 1997	Various clarifications and amplifications
3	Aug 1998	Various amendments including steel sleepers; ballast shoulder widths; temporary rail joints; gauge widening on curves.
4	Jun 2000	Revised to allow for speeds above 125 mph and CEN 60 rail.
5	Feb 2002	Inclusion of RT60 S&C; requirements for increase of speed etc. on existing track; ballast gluing, rail lubrication, securing of material for lineside safety; transfer of some text from RT/CE/S/011
6	June 2010	Reformat to Network Rail document, change of title to <i>Design and construction of track</i> and renumbered to NR/L2/TRK/2102. Job titles updated to reflect new organisational structure. Inclusion and expansion of requirements previously published in NR/SP/TRK/101 and GC/RT5021.
7	Dec 2015	Scope of document limited to 140mph. Updated with the addition of new requirements on; materials, forces, requirements for CWR (from NR/L2/TRK/3011), requirements for geometry design (from NR/L2/TRK/2049), formation and track stiffness, guard rails, structures, gradients, design and risk assessment of S&C layouts, minimum radius of switches, rail depths through level crossings, use of transition rails, ballast compaction and shoulder removal, concrete bearers for cable management, CWR on tight radius curved track, maximum lengths of rail in jointed track, calculation of joint closing temperatures, use of semi-fabricated crossings, types of S&C to be used above 125 mph, installation of bi-axle grids on S&C renewals, use of anti-creep devices in S&C, use of bearer ties, maximum lengths of rails in jointed S&C, conversion of jointed track to CWR (from NR/L2/TRK/3011), types of S&C suitable for speeds in excess of 125 mph, conversion of freight lines to passenger use, decommissioning of redundant assets.

Compliance

This Network Rail standard is mandatory and shall be complied with by Network Rail and its contractors if applicable from 01 May 2016 or sooner when briefed.

When this standard is implemented, it is permissible for all projects that have formally completed GRIP Stage 3 (Option Selection) to continue to comply with the issue of any relevant Network Rail standards current when GRIP Stage 3 was

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completed and not to comply with requirements contained herein, unless stipulated otherwise in the scope of this standard.

Reference documentation

BS EN 13146, *Railway applications – Track – Test methods for fastening system*

BS EN 13481, *Railway applications – Track – Performance requirements for fastening systems*

NR/L2/TRK/001, *Inspection and Maintenance of Permanent Way*

NR/L2/TRK/0032, *Joining Of Rails By Aluminothermic Welding*

NR/L2/TRK/0132, *Maintenance Arc Welding of Rails, Switches and Crossings*

NR/L2/TRK/2049, *Track Design Handbook*

NR/L2/TRK/2500, *Engineering Assurance Arrangements for Track Engineering Projects*

NR/L3/TRK/3011, *Continuous Welded Rail (CWR) Track*

NR/L2/TRK/3038, *Longitudinal Timbers – Design - Installation and Maintenance*

NR/L2/TRK/3100, *Topographic, engineering, land and measured building surveying – Strategy and general*

NR/L2/TRK/3201, *Management of Tight Clearances and Track Position*

NR/L2/TRK/4040, *Level Crossing Surface Systems*

NR/L2/TRK/4100, *Serviceable Concrete Sleepers for use in running lines and sidings*

NR/L2/TRK/4239, *Track Bed Investigation, Design & Renewal*

NR/L2/TRK/8100, *Track Ballast and Stoneblower Aggregate*

RT/CE/S/050, *Process for Cold-Expanding New Fishbolt Holes by the Split Sleeve Method*

RT/CE/S/051, *Process for Cold-Expanding Existing Fishbolt Holes by the Split Sleeve Method*

NR/L3/EBM/089, *Asset Management Plan*

NR/L3/CIV/005, *Railway System Drainage Manual*

NR/L3/TRK/4004, *Switch & Crossing Assemblies*

NR/PS/TRK/029, *Wood Sleepers and Bearers and Longitudinal Timbers*

NR/SP/CIV/044, *Design & Construction of Undertrack Crossings (RT/CE/S/044)*

NR/SP/OHS/069, *Lineside Facilities for Personnel Safety (RT/CE/S/069)*

NR/SP/SIG/19812, *Cross Track Cable Management*

NR/SP/TRK/9003, *Installation and Maintenance of Longitudinal Timbers*

RE/PW/572, RE/PW/590, RE/PW/759, RE/PW/2020. *Drawings.*

RE/PW/1600 and 2000 series drawings for NR56 and NR60 S&C respectively

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RT/CE/P/027, *Use of Ballast Gluing to increase the Lateral Resistance of Track*

RT/CE/S/002, *Serviceable rail for use in running lines and sidings*

RT/CE/S/008, *Saw and Disc Cutting and Drilling of Rail*

RT/CE/S/009, *Track Ballast Returned by Automatic Ballast Cleaners*

RT/CE/S/021, *Steel sleepers*

RT/CE/S/030, *Concrete Sleepers and Bearers*

RT/CE/S/052, *Rail and Baseplate Pads*

RT/CE/S/061, *Pearlitic Rails*

GC/RC5633, *Recommendations for the Risk Arresting Devices and End Impact Walls*

GC/RT5212, *Requirements for Defining and Maintaining Clearances*

GE/RT8012, *Controlling the Speed of Tilting Trains through Curves*

GI/RT7016, *Interface between Station Platforms, Track and Trains*

GI/RT7033, *Lineside Operational Safety Signs*

GM/RT2141, *Resistance of Railway Vehicles to Derailment and Roll-Over*

GM/RT2142, *Resistance of Railway Vehicles to Roll-Over in Gales*

Sectional Appendix

Disclaimer

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1 Purpose

This standard is intended to control the risk of incorrect materials and components being specified and to control the required quality of installation of track. It specifies the design principles and minimum standards for the construction of new or relayed track, including the materials to be used. It also specifies acceptance criteria for new or relayed track in terms of workmanship and the track geometry requirements for both newly installed and existing track.

2 Scope

This Network Rail standard specifies the requirements for the design and construction of track with line speeds up to 140mph. This includes:

- a. the construction of new sections of track, and routes;
- b. the replacement of contiguous lengths of track components or switch and crossing layouts, either singly or in combination, as part of project or renewal activities;
- c. the replacement or new construction of trackbed layers, drainage, level crossings, direct fastening systems, buffer stops or other track fixtures;
- d. the replacement of components of the track system, carried out during maintenance, that significantly changes its design or configuration (for instance the installation or removal of check rails or the installation of cast crossings with welded extension legs in place of semi-fabricated crossings);
- e. the requirements to be met whenever existing tracks are upgraded to carry higher speeds or tonnages of rail traffic; and
- f. the requirements for the design of track geometry for both newly installed and existing track.

This standard applies to those who specify, design or supervise the installation of new track and those who design alignments on existing track.

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3 Definitions

For the purpose of this standard, the following terms and definitions apply.

absolute track geometry

See **managed track position**

adjustment switch

scarf joint installed at the junction of continuous welded rail and jointed track to accommodate the expansion and dissipate the thermal forces from the continuous welded rail track.

NOTE Adjustment switches may also be used to permit some types of bridges to expand and contract without impacting upon the track system, when adjustment switches are used in this application they are referred to as 'expansion joints'.

automatic mode (OTM operation)

application of the tamper or other on-track machine with varying down pressure to remove cross level error.

ballast

nominally single-sized granular material of specified properties, placed on the blanket (where provided), subgrade or structure to provide vertical and lateral support to the sleepers or bearers.

ballast shoulder

ballast placed at the ends of sleepers and bearers to provide lateral stability to the track.

bearer tie

a component used to connect concrete bearers, designed such that in service they behave as one continuous bearer.

bearing change

an abrupt change in horizontal alignment where the connecting straights are not tangential.

cant (superelevation, or crosslevel)

the vertical difference in height of the two rails of a track measured at the centre lines of the heads of the rails. It is positive when the outer rail on a curve is elevated above the inner rail, and negative when the inner rail on a curve is raised above the outer rail.

cant deficiency

the difference between the applied cant on the track and the equilibrium cant for the vehicle at the particular stated speed.

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cant gradient

indicates the amount by which the designed cant (superelevation or crosslevel) is increased in a given length of track, normally expressed as a rate e.g. 1 in 1200.

cascaded rail

rail that has previously been installed in track and is picked up as CWR and moved directly to a new site.

Cast centre block

a crossing, the nose(s) and throat (knuckle) of which are made as one casting. The leg end extensions are attached by flash butt welding and the non-load carrying wing rails by multiple groove locking (MGL) pins, tension-controlled bolts or similar devices.

cast crossings

cast crossings are manufactured from cast steel either as a complete unit (i.e. monobloc) or as a cast centre block crossing with welded-on extension leg ends

NOTE: Some cast centre block crossings will have bolted wing rail extensions.

cast vee

crossing in which a cast nose-piece is flash butt welded to pearlitic rail legs and to which the wing rails are attached by MGL pins, tension-controlled bolts or similar devices.

catch points

trailing switches provided to derail vehicles running in the wrong direction.

*NOTE: See also **trap points**.*

CEN60 S&C

S&C using CEN60 rail, examples being RT60 & NR60.

check gauge

distance between the running edge of a running rail and the bearing face of the opposite check rail, measured at right angles to the rails in a plane 14 mm below their top surface.

check rail

rail or special section provided alongside a running rail at a specified dimension inside gauge to provide a flangeway, to give guidance to wheelsets by restricting lateral movement of the wheels.

circular curve

a curve of constant radius.

co-ordinate geometry design

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design of track alignment and layouts working within a system of three-dimensional spatial co-ordinates tied to a primary survey reference grid.

NOTE: This is normally achieved based upon a survey using 'total station' techniques, and the provision of fixed datums used subsequently for setting-out and control of installed position.

common crossing

cast or fabricated portion of the track layout that enables the rails of the two tracks to cross each other, while still providing support and guidance for smooth passage of the vehicle's wheels.

there are of four types:

- a) Cast crossings, monobloc or cast centre cast;
- b) Semi-fabricated with cast or machined nose;
- c) Semi-fabricated with electro-slag welded vee; and
- d) Fully-fabricated crossings.

compound curve

a curve formed of two similar flexure circular curves of differing radii, which should normally be connected by a transition curve.

configuration

arrangement of rails, switches, crossings, baseplates, bearers and sleepers into a standard design.

continuous welded rail (CWR)

- rails installed in the track that have been welded together to form a single rail greater than a nominal 36 m in length;
- track constructed with continuous welded rail.

derailment containment kerb

arrangement to prevent a derailed rail vehicle or train coming in to contact with parts of a structure that would be liable to severe damage if so struck or to prevent vehicles falling from a major bridge or viaduct.

design speed

the speed in miles per hour for which a stretch of track or turnout in S&C is to be or has been designed. Speeds will normally be governed by curvature and its associated cant. Speeds can also be affected by clearances, signal sighting or other engineering requirements.

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designed alignment standard deviation

the calculated standard deviation for the designed alignment See *also standard deviation*.

direct fastening

rail fastening system where the rail is fastened directly to its supporting bridge deck or slab system without a baseplate or chair.

electro-slag welded vee

crossing manufactured from two machined pearlitic rails and an insert bar, which is then electro-slag welded together and the finished vee machined to profile. Wing rails are then attached by means of tension-controlled bolts or similar devices.

enclosed flangeway

a flangeway that is enclosed at the bottom and on both sides, e.g. the flangeway between the vee and wing rails in a cast crossing.

enhanced permissible speed

the highest permitted speed (higher than the permissible speed) applying to a specific type of train over a section of line operating at cant deficiencies in excess of those permitted at the permissible speed. There may be more than one enhanced permissible speed applicable to a given section of line, depending on the characteristics of the particular train fleet.

equilibrium cant

the cant at a particular speed at which the vehicle will have a resultant force perpendicular to the running plane of the rails.

equilibrium speed

the speed of a vehicle on a curve with a particular cant such that the resultant force of the weight of the vehicle and the effect of centrifugal force is perpendicular to the running plane of the rails. The vehicle is then said to be in equilibrium.

exceptional design values

where the requirements of the business cannot be met by using normal or maximum design values it is permissible to use exceptional design values. The reason and implications for their use shall be justified and subject to approval.

expansion joint

- non-insulated fishplated which is designed to accommodate longitudinal thermal expansion of the rails, also known as ordinary fishplated joint; or
- scarf joint used to permit structures to expand and contract without impacting upon the track system, see *also adjustment switches*.

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fish-plated cast monobloc

crossings where the individual constituents (vees, wing rails, legs etc) are cast together as one piece and attached to the plain rail using a fish-plated connection.

fixed track position

See **managed track position**

flangeway gap

gap provided to permit the passage of the wheel flanges of rail vehicles, for example between a check rail and a running rail, or between a level crossing deck and the running rail.

*NOTE: Sometimes referred to as **free wheel clearance***

formation

material on which the ballast is placed, consisting of the subgrade plus blanket and other protective layers (if present).

frangible platform

a platform that is designed to collapse in a controlled manner as a result of impact , usually from sliding or friction buffer stops.

free wheel passage (at check or wing entry)

dimension between the working face of the crossing check rail or wing rail and the gauge face of the running rail opposite across the gauge measured at the entry to check rail or wing rail respectively.

free wheel passage (at crossing nose)

dimension between the working face of the crossing wing rail and check rail opposite across the gauge.

free wheel passage (in switches)

dimension from the gauge face of the switch rail to the back face of the open switch rail.

Freight only line

track carrying only freight traffic.

full depth switches

switches where both stock and switch rails are manufactured from BR109, BS110A, BS113A or CEN56 rail sections.

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fully fabricated crossing

crossings made by machining rolled rails to produce a point rail and a splice rail fastened together with bolts or multi-groove locking pins. The wing rails are produced from rolled rail and are fastened to the vee by bolts or multi-groove locking pins.

guard rails

additional rail or rails fixed parallel to the running rails and intended to restrain derailed vehicles.

hand of switches

the “set” of a switch.

NOTE: Observe from the switch fronts looking towards the crossing - if the right hand stock rail has a set or “kink” to the right it is a right hand turnout. Similarly, a left hand stock rail with a set will define a left hand turnout. If both stock rails having a very small set in opposite directions the turnout would be defined as an “equal split”.

handpoints

See **unworked points**.

high cant deficiency curves

curves where specific train fleets have permission to run at cant deficiencies in excess of 150 mm.

jointed track

method of track construction where rails are joined together by ordinary fishplates, with an expansion gap between rail ends and not exceeding 37m long.

kicking strap

a device attached to a switch rail near to the toe which passes under the stock rail of a set of switches or under the wing rail of switch diamonds to prevent upward movement of the switch rail.

lateral resistance plate

generic term applied to devices that are fitted to sleepers or bearers to enhance lateral resistance to thermal and traffic forces.

length (of a track panel)

length of a track panel normally taken as 60ft or 18288 mm.

NOTE: Used in the context of the number of sleepers per length, 28/L being 28 sleepers per 60ft of track.

level crossing

intersection at the same level of a road, footpath or bridleway and one or more railway tracks.

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longitudinal timber

timber parallel to and supporting a running rail.

machined nose block

crossing where the vee is mechanically manufactured from a low alloy wrought steel block, which is machined and subsequently heat treated. Pearlitic rail leg ends are flash butt welded to the vee. Distance blocks are also welded directly onto the vee prior to attaching wing rails by means of MGL pins, tension-controlled bolts or similar devices.

managed (or fixed) track position

generic term for all systems (including the system of “absolute track geometry” installed on West Coast Main Line) for the upkeep of track geometry and alignment by reference to datum points fixed in space.

NOTE: It is used to monitor and control the position of the track, rather than the use of relative geometry.

new construction

construction of a new railway or the construction of track on previously abandoned formation.

non-ballasted track

track that is not supported on ballast, for example; concrete slab track, track on longitudinal timbers and directly fastened track on bridges.

NR56 S&C

Network Rail design of S&C using CEN54 shallow depth rail & CEN56 rail sections, NR56 is an updated version of BS113A Vertical S&C.

NOTE: The design is documented on the RE/PW/1600 series drawings

NR60 S&C

Network Rail design of S&C using CEN60 rail sections.

NOTE: It is based around the family of CEN60 rail sections, the design is documented on the RE/PW/2000 series drawings.

obtuse crossing

assembly to permit the passage of wheel flanges where two rails intersect at an obtuse angle.

ordinary or expansion fishplates

non-insulated connection of two rails by means of fishplates designed so that when assembled as a joint the rails are free to expand and contract within limits.

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P2 forces

P2 is a lower frequency peak force caused by the track being pushed down by the passage of a vehicle generally below 100Hz.

parallel tamping

use of two or more specialist S&C tamping machines, working together to achieve the simultaneous lining, lifting and packing of adjacent tracks.

part bearer

the portion (A, B or C) of a bearer that has been split into sections and joined together with bearer ties.

permissible speed

the maximum speed over a section of line that applies to trains not travelling at enhanced permissible speeds (i.e. not tilting trains).

plain line

track not incorporating switches and crossings.

NOTE The term "plain line" therefore excludes the through route of S&C.

plane of the rails

flat plane projected across the crown of the two running rails of a track.

premium hardened rail steel

any grade of rail steel harder than grade 260R.

Head of [XXXX]

The Network Rail Head of the engineering discipline shown in the brackets.

rail fastenings

any device used to secure running rails into chairs or baseplates or directly to sleepers, bearers or other rail supports.

raised guard rails

additional rails fixed higher than, parallel to and inside or outside of the running rails. Intended to prevent vehicles from derailling.

rate of change of cant or cant deficiency

the rate at which a vehicle experiences the change in cant or cant deficiency, measured in mm per second.

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rate of rotation of vehicle body

the rate of rotation experienced by a passenger on a train, measured in mm per second; for a tilting train this is the sum of the rate of change of cant and rate of application of tilt.

reverse curve

a curve formed by two circular curves of opposite hand, which should normally be connected by transition curves.

RT60 S&C

design of S&C developed by Railtrack as a first step towards introducing S&C based around the family of CEN60 rail sections.

NOTE: The design has now been superseded by NR60.

running line

line shown as a running line in Table A of the Sectional Appendix.

Sectional Appendix

document that contains details of all permissible and enhanced permissible speeds for a particular route.

self-tensioning fastenings

fastening system that achieves the required tension through insertion without the need for any post-tensioning through tightening of screws or nuts, etc.

semi fabricated crossing

semi fabricated crossings made by either:

- a) machining and welding rolled rails to produce a crossing vee; or
- b) using a cast vee;

which are then fastened to wing rails manufactured from rolled rail using bolts or multi-groove locking pins.

serviceable rail

rail that has previously been installed in track but has been recovered and re-manufactured, i.e. taken to a depot, examined, defects removed, and flash butt welded back together.

slab track

track without ballast supported by continuous reinforced concrete slab.

sleeper

transverse beam that provides vertical and lateral support to plain line running rails, rail fastenings and where appropriate check rails, guard rails, conductor rails and ancillary operating equipment.

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soleplate

a metal plate fitted at the toes of switches to fix the track gauge and, on power operated points to control the position of the point operating mechanism relative to the switch and stock rails.

standard deviation

measure that describes how a set of values are dispersed around the mean value.

NOTE: It is applied to the measurement of track geometry quality, the range of variation in top (vertical alignment) and line (lateral alignment) over a fixed length, normally an eighth-mile, are set out as standard deviations. These are then used to monitor the achievement of targets, by speed bands or ranges.

Standard Track Drawings

drawings of track components or standard designs published under the 'RE/PW' series of drawings.

stress free temperature

the rail temperature at which the rail is the same length as it would be in an unrestrained state and at which, therefore, there is no thermal force present.

stressing (of rails)

the process of extending continuous welded rail (CWR) so that the stress free temperature of the rails is within a specified temperature range.

strengthened (switches)

prefix added to descriptions of older designs of switches and crossings to reflect that they were designed to withstand thermal forces, e.g. with stress transfer blocks secured with 8 high tensile bolts.

strengthening rails

additional rails fixed parallel to the running rails and intended to increase the lateral resistance and weight of the track to reduce risk of buckling.

stretcher bar

bar that connects together the two switch rails of a set of switches to maintain flangeway gaps.

strings

lengths of new rail (between 18 and 108m long) flash butt welded typically up to lengths of 216m for transportation and installation.

structure

something built to support or retain a load.

NOTE: Includes bridges, platforms, viaducts, tunnels and culverts, but excludes earthworks.

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structural adjustment switch

an adjustment switch specifically designed to accommodate additional structural movement up to +/- 300mm. They are designed with the switch rails as a fixed end and a moveable stock rail to accommodate extra movement at specific locations. They can operate over long lengths without affecting the track gauge whilst maintaining continuity of rail profile and inclination. They are designed and installed directly across the structure's expansion joint to suit the direction of movement and lie in either the facing or trailing direction.

subgrade

prepared surface of the uppermost layer of naturally-occurring or fill material upon which the railway is constructed.

switch and crossing (S&C)

track incorporating switches and/or crossings that allows one track to cross another or diverge from or merge with another.

switch diamonds

set of switch diamonds consists of two obtuse crossings in which the obtuse point rails are replaced by switch rails and a check rail is not required.

switches

set of switches consists of two fixed stock rails with their two associated moveable switch rails.

tight joint

non-insulated connection of two rails by means of specially drilled fishplates and high tensile bolts but without an expansion gap between the rail ends.

track gauge

distance between the running edges of the rails in a track, measured without load at right angles to the running edges of the rails in a plane 14 mm below their top surface.

track renewals

replacement of plain line or S&C carried out under the domestic track renewals programme or included in an enhancement or remodelling project.

track system

assemblage of rails, rail supports, rail fastenings, sleepers, timbers or bearers and ballast, acting together to provide guidance and support for rail vehicles.

NOTE: The term also applies to other types of construction such as non-ballasted track.

Track System Designer

engineer responsible for the design of the track engineering elements of the infrastructure system.

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trackbed

general term referring to the ballast, blanket and subgrade.

trackbed layers

general term referring to all layers placed between the subgrade and the underside of sleepers or bearers.

train operated points

points that are designed for use in running lines with facing movements in the normal position only.

NOTE: They are operated by the passage of trains in the trailing reverse direction. They are restored to the normal position by the point operating mechanism after the passage of each train. "Hydro-pneumatic self restored points" are a type of train operated points.

transition beam

a connecting unit installed between ballasted track and track fastened directly to slab track or to a bridge deck to provide a gradual change from the stiffness of one form of construction to that of the other.

transition curve

curve of constantly varying curvature. It is normally provided between two lateral circular curves of differing radii, or between a lateral circular curve and a straight. If the variation is linear, the transition is in the form of a clothoid, often approximated by a cubic parabola. Non-linear forms such as sine and cosine curves are also available.

trap points

facing switches provided at an exit from a siding or converging/diverging line to derail vehicles making an unauthorised movement, so protecting the adjacent line.

twist (design)

an intentional discontinuity in rail inclination between vertical and inclined track (twist rail) or a cross level variation such as a cant transition curve above normal limits.

twist (fault)

a difference in crosslevel over a short distance (usually measured over 3m) that is greater than a predetermined amount (usually 15mm).

Normally expressed either as an average gradient over 3m or as a dimension in millimetres by which the crosslevel varies over 3m.

unworked points

points not controlled by the signalling system, other than train operated points.

NOTE: Hand points, runaway catch points and spring operated points are examples of unworked points.

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vertical curve

curve joining two track gradients in their vertical alignment.

vertical S&C (CEN56)

design of S&C developed by British Rail and introduced in the mid-1960s to replace earlier bullhead and flatbottom designs.

Current designs of CEN56 Vertical S&C are known as 'NR56'.

NOTE: It is based around the BS113A rail section (now CEN56) and derives its name from all rails being without any inclination (i.e. vertical).

virtual transition

the name given to the 'transition effect' formed by the bogie centres of a vehicle when traversing between two elements not joined by a transition. Normally taken as being 12.2 m long, the bogie centres of a Mk 1 coach.

Welded cast monobloc

a crossing, all of the components of which (vees, wing rails, legs etc.), are cast as one piece. The structure is made weldable into CWR by the incorporation of flash butt welded leg end extensions using stainless steel inserts.

'within S&C'

S&C and closure panels with S&C bearers up to 18.288m beyond the switch fronts and 36.566m beyond the last long bearer.

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4 Track design policy – business outputs, systems and materials

4.1 Business outputs

NOTE: The design, specification and installation of the track system requires the consideration and balancing of constraints to arrive at a solution that achieves the required business outputs, eliminates hazards and reduces likely risks from hazards where elimination is not possible.

Where the design is produced by a supplier external to Network Rail, an iterative development of the design with informed input from the Network Rail client representative will enable the delivery of an optimal solution which takes account all of the business outputs.

To achieve the business outputs, new track systems, components, and track layouts shall be developed taking account the interfaces with other railway infrastructure and systems and Health and Safety considerations.

The following principles should be taken into account during the design development:

- a) be compliant with relevant statutory, legislative, and company standards and other requirements;
- b) be cost-efficient at construction and installation whilst considering the future ease of maintenance, inspection, operation and upkeep and repair (in accordance with the company ergonomics policy and standards). An optimal solution should be targeted at achieving the lowest whole life cost within the railway system whilst taking account of railway access constraints and costs;
- c) have the designed capability and functionality informed by Asset and Route policies;
- d) have opportunities for change (enhanced or reduced capability or functionality), and interdependencies with other asset types identified and considered;
- e) be capable of delivering improved reliability and minimising loss of functionality, performance or capability;
- f) minimise the need for human examination and intervention, and separate these activities from train movements and live electrical equipment;
- g) exploit, wherever practicable, standard or “modular” designs, products, and layout configurations;
- h) minimise the identification and application of new products and techniques to avoid unnecessary diversity and complexities of training and competence for constructors, operators and maintainers. Alternative products are only to be used where there are business benefits that outweigh the risks and costs of diversification;
- i) have material specified from sustainable sources in accordance with the company Corporate Responsibility Policy;
- j) where practicable and where required by the route policy, be designed to be installed in possessions of 8 hours duration;

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k) where appropriate, be designed to enable components to be changed or repaired and the track restored to line speed in a working time of 4 hours.

Particular attention should also be given to the following aspects in planning for and during the installation:

- l) development of standardised installation methods and techniques, to enable consistency of approach;
- m) make the best use of the available railway access opportunities for productive work whilst maintaining a consistent high quality of delivery;
- n) care in the transportation, handling and storage of materials so that installed quality is not impaired;
- o) information and records of new or renewed assets added to asset information repositories as soon as the assets are brought into operation or accepted back on issue of the final completion notice.

4.2 Design of new track systems

4.2.1 General

All systems, sub systems and components shall be designed to comply with Company Standards, Railway Group Standards, Technical Specifications for Interoperability and where appropriate European Norms (EN's).

New track systems should be designed and constructed to achieve the required business outputs with the minimum of inspection and maintenance.

The design should include a combination of maintenance, refurbishment and renewal interventions to achieve the lowest whole life cost for track assets. It should include the interface with existing assets taking account of their condition and design.

Risks to track workers are greatest when they are on or close to the track; therefore the initiatives to reduce time on track, or at least when it is safer, will also reduce the overall worker safety risk.

When reviewing systems for acceptance if the designed service life, inspection or maintenance intervention frequency cannot be achieved the implications should be recorded and the impact assessed.

4.2.2 Service lives

For product and systems approval, new designs of track and track components should be developed with the aim of achieving the following service lives.

A design life for Sleepers, bearers, baseplates and rails in normal service conditions of:

- *CEN60 track systems*: the lesser of 1200 EMGT or 60 years for plain line and 1000 EMGT or 60 years for S&C;

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- *CEN56 track systems*: the lesser of 1000 EMGT or 60 years for plain line and 800 EMGT or 60 years for S&C.

Sub-elements, e.g. ballast, rail pads, rail insulators, and rail fastenings, rail lubricators, switches and crossings, switch rollers, and insulated rail joints may have a design life of half of the sleepers, bearers and rails.

Formation treatment should have a design life of 60 years.

4.2.3 Inspection and maintenance intervention

A track system comprising of conventional CEN60 ballasted track should be designed to be compatible with an inspection and maintenance regime as follows:

- a four-weekly geometry recording;
- a thirteen-weekly visual track inspection cycle; and
- a two yearly possession of the line for component and mechanised maintenance increasing to annual for the last 25% of the service life of the system.

Switch and crossing systems may receive additional visual inspections, typically four-weekly.

CEN56 ballasted track systems installed in lower category routes should be capable of similar performance but with less frequent geometry recording, typically eight-weekly, rising to six-monthly on Category 4, 5 and 6 track.

4.3 Materials

All materials and components used in the design of new track systems shall have their performance assessed against an operating temperature range of -27° C to +60° C.

Failure to achieve the required performance levels at the extremes of the temperature range will not necessarily prevent acceptance. The impact on performance should be recorded, its criticality assessed, and the need for additional mitigation determined.

4.3.1 Identification of components

Components used in the track system shall be marked such that the identity of the component, manufacturer and year of manufacture can be determined.

Identifying marks should be applied in a manner that will not damage the item or impede its operation. They should be large enough and formed with sufficient clarity to be readable over the life of the product. They should be positioned (as far as is practicable) to be readable after installation.

Additional information such as month of manufacture, batch number or individual serial number may be necessary depending on the criticality of the component.

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5 Track system specification

5.1 General

The minimum engineering requirements for design of the track system are specified in this section. These apply to the design of both running lines and sidings unless stated otherwise.

NOTE: Compliance to clause 6 onwards will enable the construction of a compliant asset.

5.2 Track system specification

For the purposes of acceptance of design, any proposed track (system or component) shall be compared to the standard designs for plain line and S&C, where the baseline is; CWR, straight track, CEN56 rail, 26 concrete monobloc sleepers per 60 ft (18.3 m), S&C with concrete bearers at 710 mm nominal spacing, rail fastenings with a nominal toe load of 6.5 kN and fully ballasted sleeper beds and shoulders.

Track with rails less than 30 m long shall be considered to be jointed track.

Track not classified as 'jointed' shall be deemed to be CWR. It shall be designed in accordance with **1.1**

The standard length of rails in jointed track is 18.288 m and installed with fishplated expansion joints.

In this standard, the track system comprises the entire track structure, e.g. for conventional ballasted track, the subgrade, formation, drainage, ballast, sleepers, rails, fastenings, and the geometry of the track and its relative position (gauge clearance) to structures, vehicles and other features.

5.3 Track gauge and flangeways

New track system designs shall have a minimum track gauge of 1435 mm, a minimum flangeway depth of 55 mm and a minimum flangeway width of 60 mm where back of flange contact is not intended (typically through switches and level crossings).

See **5.9** for additional requirements for S&C.

5.4 Rail inclination

In plain line track, rails shall have an inclination of 1 in 20 towards the track centre line.

In S&C, depending on the design of S&C, rails shall either have an inclination of 1 in 20 towards the track centre line or be vertical.

In two levelling S&C with vertical rails the running rails may, as a result of the two-levelling, become inclined away from the four-foot relative to the plane of the rails.

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Where rails in S&C are vertical, the rails in short lengths of adjacent plain line may also be vertical.

Twist rails or twist transition baseplates shall be used to accommodate the change in verticality from inclined track to vertical track.

5.5 Forces

The track system shall be designed to have performance characteristics capable of sustaining the following forces:

- a maximum static axle load of 250 kN (25.5 tonnes);
- a vertical dynamic force, generated by the static wheel load and the low frequency dynamic forces P2, of 350 kN per wheel and an occasional isolated vertical load of 500 kN per wheel;
- a lateral force generated by a train of 100 kN over a length of 2 m;
- a lateral force on check rails of 135 kN over a length of 2 m and 50 kN at any one mounting position;
- a lateral force on guard rails of 100 kN over a length of 2 m;
- a longitudinal force of 1200 kN per rail to allow for train acceleration and braking; and
- be capable of resisting thermal forces which may be expected to occur over a rail temperature range of -14°C to +53°C, without distortion (equal to a tensile force of 700 kN and a compressive force of 620 kN).

5.6 Rail

Rails shall be designed to provide support taking account of speed, axle load and tonnage.

The rail section including the head profile shall have compatibility with sections already existing in Network Rail's infrastructure and wheelset profiles in use.

The metallurgy and manufacturing process for rail shall be subject to acceptance by Network Rail in order that:

- the rails are capable of being butt welded together (using a Network Rail approved process);
- minimum actions (to be taken upon discovery of defects) can be defined; and
- withdrawal criteria (for when rails reach their wear limits) can be defined.

NOTE: See RT/CE/S/002 and RT/CE/S/061 for the specification of rail.

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5.7 Rail fastenings

Rail fastenings shall:

- a) hold rails securely in the rail seat (unless designed specifically to do otherwise);
- b) limit rotation of the rail about the outer edges of the rail foot;
- c) minimise longitudinal movement of rails through creep and thermal forces (unless designed specifically to do otherwise);
- d) assist in retention of the track gauge; and
- e) not cause damage to the rail.

Additionally they shall;

- f) meet the requirements of BS EN 13481;
- g) have been tested by methods specified in BS EN 13146; and
- h) have Network Rail Product Acceptance.

NOTE: The preferred type of rail fastening is self-tensioning when installed. Non-self-tensioning types of rail fastening may only be used in special applications.

5.8 Sleepers and bearers

Sleepers and bearers shall be designed with a soffit area, at the specified spacing, to distribute loads to the ballast without overstressing the ballast, formation or subgrade.

Sleepers and bearers shall have an end area to provide adequate lateral restraint to the track.

Rail and baseplate pads in S&C should, as far as possible, replicate the stiffness of plain line.

NOTE: See RT/CE/S/021, NR/PS/TRK/029 and RT/CE/S/030 for the specification of steel, timber and concrete sleepers and bearers.

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5.9 Switches and crossings

5.9.1 Maximum and minimum values

The values shown in **table 1** shall be applied in the design of new standard designs of S&C. Installation and maintenance tolerances shall apply in addition to these values.

Table 1 – Switch and crossings maximum and minimum values

S&C		Value mm
Minimum opening at the toes of switches		100
Maximum free wheel passage in switches		1375
Minimum fixed nose protection for common crossings	1432 mm gauge S&C	1391
	1435 mm gauge S&C	1394
Maximum free wheel passage at crossing nose	1432 mm gauge S&C	1350
	1435 mm gauge S&C	1353
Maximum free wheel passage at check/wing entry		1360
Minimum flangeway width		38
Nominal flangeway width through check rails and wing rails (excluding the knuckle area of obtuse crossings)		41
In fixed obtuse angle crossings, minimum flangeway clearance between the check rail and the wing rail at the knuckle of the crossing.		48
Minimum flangeway depth:		
• through enclosed flangeways		55
• elsewhere		51
Maximum permissible unguided length in obtuse crossing.		As specified in GM/RT2466
Maximum excess height of check rail in obtuse crossings		38
Maximum theoretical cant deficiency at switch toes:		
a. Up to 40mph		120
b. Between 45 and 105mph		105
c. Between 110 and 125mph		85
Minimum flangeway gap at the nose of swing nose crossings		85
Free wheel clearance elsewhere through swing nose crossings		1375
NOTE 1: Where switch diamonds are operated by a rail clamp point lock mechanism (clamp lock), it is permitted to reduce the opening at the toe to a minimum of 85 mm		
NOTE 2: Gauge is measured 14 mm below the running surface.		
NOTE 3: Manufacturing tolerances are given in NR/L3/TRK/4004, installation tolerances in Appendix A.		
NOTE 4: Cant deficiency at switch toes is measured using a 12.2m chord centred on the switch toe.		

The maximum construction depth (bearers, soleplates, baseplates, pads and rail) for new designs of S&C shall be 405mm.

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5.9.2 Common crossings

Common crossings shall be protected by check rails.

New designs of cast common crossings should comply with RT/CE/S/012 and will normally have welded legs.

Part-fabricated crossings with welded or cast vees may be used on lower category lines. Fabricated crossings will normally be restricted to sidings.

See 11.5.2 for the restrictions on the use of fabricated and part fabricated crossings.

5.9.3 Swing nose crossings

Swing-nose crossings shall be used where the angle is flatter than 1 in 35.

5.9.4 Obtuse crossings

Obtuse crossings shall not be used where the line speed exceeds 105 mph.

Cast obtuse crossings shall incorporate check rails to protect the wheel transfer area of the opposite crossing.

The crown or top of the check rail on cast obtuse crossings shall be raised by 38mm to provide greater protection.

See 11.5.3 for other restrictions on the use of obtuse crossings.

5.9.5 Check rails

The wheel transfer area between crossing nose and wing rail of fixed crossings shall be protected on the opposite running rail by a check rail on each route.

The crown or top of the check rail shall not be lower than crown of the adjacent running rail.

Raised check rails shall only be used with obtuse crossings.

The desirable slope of the main flare should be 1 in x (where 'x' is the speed in kph).

5.9.6 Stretcher bars and soleplates

Stretcher bars (or an approved equivalent) shall be used to connect together the two switch blades of a set of switches.

Their length shall be such that when fitted the designed Free Wheel Passage is achieved. The number of stretcher bars in standard switch designs shall be as shown on the relevant standard drawing; there shall be at least two.

At the switch toe, a "kicking strap" shall be provided with between 3 mm and 9 mm clearance under the foot of the stock rails.

A soleplate or steel bearer (according to the type of point operating mechanism) shall be provided at the toe position.

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Where the point operating mechanism is positioned on the bearer ends the soleplate (or steel bearer) shall extend to fix the relative position of the drive and detection equipment relative to the switch and stock rails.

Stretcher bars and soleplates shall be insulated to meet signalling requirements.

5.9.7 Point operating system

In running lines, the switch rails of turnouts, switch diamonds and the noses of swing nose crossings shall be equipped with means of detecting that the movable rails are in their correct position and are locked.

Provision for temporarily securing both the open and closed switch out of use shall be provided.

5.10 Design of continuous welded rail track systems

5.10.1 Design of CWR - General

Continuous Welded Rail (CWR) shall be stressed to a target Stress Free Temperature (SFT) of 27° C.

- a) the minimum SFT shall be 21° C;
- b) the target SFT, achieved by tensor or thermal stressing, shall be 27° C;
- c) the target SFT achieved by natural stressing shall be between 24 and 30° C when clipped down.

CWR on Crimp ended steel sleepers shall have a minimum SFT of 26° C, be stressed to a target SFT of 32° C and natural stressing clipped down between 29 and 35° C.

5.10.2 CWR - Tunnels

- In tunnels longer than 180m CWR, track between two points 40 m into either end of the tunnel may be fastened down at ambient temperature.

5.10.3 CWR – Slab track

The target SFT for CWR on slab track shall be 21° C.

5.10.4 CWR - Switches and crossings

Any S&C unit incorporated into CWR shall be capable of withstanding longitudinal thermal tensile and compressive forces.

CWR-compatible S&C shall be welded or fitted with tight-joint or insulated fishplates approved for use in CWR.

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Units installed with tight-joint fishplates may be subject to limited expansion and contraction. They should be assumed to experience and withstand the same thermal forces as units that are welded in.

S&C shall not be present within the stress transition length at the end of a section of CWR. S&C not isolated from CWR by adjustment switches shall be fully stressed. Any stress transition length shall commence clear of the S&C.

S&C units not approved for use in CWR, shall be isolated from adjacent CWR by adjustment switches positioned not more than 40m from the S&C (switch front or last long bearer).

The distance from the S&C should be taken as the distance from the switch fronts or the weld / joint at the back of the crossing to the nearest machined section of the adjustment switch

5.10.5 Switch designs suitable for use in CWR

CWR-compatible Switch designs are of two types with:

1. stress transfer blocks and bolts connecting the switch to the stock rail. Eight 25.4mm (1") diameter High Tensile Steel (HTS) bolts, tightened to a torque of 880 Nm allow transfer of 70-tonne thermal force; and

NOTE: Only those heel blocks with two bolts, or two pairs of bolts, are deemed to be stress transfer blocks.

2. creep monitors. Thermal forces in the stock rails are accommodated as in plain rail, and those in the closure rails are deemed to dissipate in the same manner as at the free end of a length of CWR. Longitudinal thermal movement occurs at the heel of the switch rail; this is indicated by a "ball-and-claw" creep monitor device, which is not intended to transfer more than 20% of the maximum thermal force.

The following designs of switch are suitable for use in CWR:

- a) BS110A/BR109 FB inclined catch point;
- b) CEN56 FB inclined catch point;
- c) CEN56 FB vertical Full depth:
 - BV (strengthened);
 - CV to HV inclusive;
 - 1:7 to 1:15 strengthened switch diamonds;
 - 1:17 to 1:28 switch diamonds;
- d) CEN56 FB vertical shallow-depth:
 - BVS to HVS
- e) RT60 C to H; or
- f) NR60 C to H.

Older inclined FB switch designs, Bull Head S&C, all designs of Slip and all designs of CEN56 Vertical scissors are not suitable for use in CWR.

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5.10.6 CWR full depth switches – lateral resistance plates

Lateral Resistance Plates are to be fitted on all Full depth timbered S&C installed as CWR as a minimum on every bearer over the length of the stock rail from the first heel block to six timbers beyond the toes. The fitment of lateral resistance plates is to be in accordance with manufacturers instructions.

Lateral End Resistance Plates (LERP) conforming to drawing RE/PW/736 shall not be used for new installations.

A castellated beam may be proposed as an alternative.

5.10.7 CWR trap and catch points

Trap or Catch points in running lines shall be CWR-compatible B or C design, with concrete bearers or hardwood timbers.

AV switches may be used in sidings or where space is limited.

Trailing, unworked catch points shall be strapped in accordance with RE/PW drawings (worked catch points are subject to less lateral thrust and need not be strapped).

5.10.8 Crossings suitable for use in CWR

All cast common or obtuse monobloc crossings or crossings with a cast centre and welded-on legs are suitable for use in CWR.

Unless the crossing has welded-on legs, the joints between the casting and the adjacent rails shall be formed by tight-joint fishplates with four 29mm (1 1/8") diameter HTS fishbolts torqued to 1020 Nm.

Wing rails on Part-fabricated common crossings shall have each wing rail secured to the adjacent vee rail by at least eight 25.4mm (1") diameter MGL pins or HTS bolts.

Fully-fabricated crossings shall not be used in CWR.

5.10.9 CWR switch diamonds

Switch diamonds that are not CWR-compatible shall be protected by adjustment switches installed on all sides positioned not more than 40m from the knuckle.

5.10.10 CWR - mixing sleeper types

The inclusion of more than 4 timber sleepers within a length of concrete or steel sleepers shall require adjustments to the critical rail temperature.

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5.10.11 Short lengths (less than 180m) of plain line between items of S&C

Plain line between S&C if welded or fitted with tight-joint or insulated fishplates shall be stressed.

S&C suitable for use with CWR can be used as part of an anchor length (but not within a stress transition length) for stressing the length of plain line. If the recommended anchor lengths are not available the length of track shall be stressed naturally.

6 Design and construction of the track system

NOTE: Compliance to clause 6 onwards will enable the construction of a compliant asset.

6.1 Design approvals and acceptance

Designs of layouts and special track forms are subject to the approval processes specified in NR/L2/TRK/2500.

All materials, components and certain processes (e.g. rail welding) used in Network Rail's infrastructure are subject to product acceptance by Network Rail, and procured against any relevant Network Rail standards.

Components and assemblies that are the subject of Network Rail standard drawings shall conform to those drawings.

Contractors and suppliers should be responsible for compliance of materials, components, processes and assemblies with the relevant specifications or drawings.

Site specific professional responsibility statements may be prepared when deemed necessary by Route Asset Managers or Heads of, for unique designs of track, for example S&C on swing or lifting bridges.

6.2 Formation, drainage and cess paths

6.2.1 Formation

The design of the formation should take account of the subgrade material and the expected traffic loading. The formation should be stable and provide adequate support to the ballast layer to enable the required standard of track geometry quality to be maintained.

Formation treatment should be designed to prevent ballast contamination by the migration of subgrade material and to direct water to the track drainage system.

Where non-ballasted track designs are adopted the formation design should be carefully designed as subsequent adjustment of the slab after settlement can be difficult and costly. The design of any non-ballasted track should take the interface with existing assets and the provision of adequate transitions into account to minimise changes in vertical deflection under loading.

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6.2.2 Stiffness of the track system

Consideration should be given to rates of change of stiffness in the design of the track system where there is a change in support conditions. This includes interfaces between ballasted track and direct fastened track and changes in ground conditions.

Further guidance is provided in NR/L2/TRK/4239.

See 7.4 for system stiffness values for new construction.

6.2.3 Formation stiffness

For track renewals the formation for ballasted track shall be designed to achieve a minimum stiffness of:

- a) Track category 1A, 1 & 2 - 45 MN/m²;
- b) Track category 3 to 6 - 30 MN/m²; and
- c) Sidings in track category 5 & 6 - 15 MN/m².

See 7.4 for formation stiffness values for new construction.

NOTE: See NR/L2/TRK/4239 for the specification of formation design and transition stiffness.

6.2.4 Track sub-grade, formation, drainage

Prior to new construction or renewal involving ballast replacement the existing formation and drainage shall be confirmed as being fit for purpose.

NOTE 1: See NR/L2/TRK/4239 for how to undertake an assessment of the existing trackbed. The results of the assessment enable a suitable standard treatment to be selected that takes into account the category of line, the drainage characteristics of the site, and the condition of the formation.

A new drainage system shall be installed where the existing drainage arrangements are inadequate in any new or renewed track.

NOTE 2: See NR/L3/CIV/005 for drainage policy, design and practice.

6.2.5 Cess paths

Where cess paths are renewed or newly constructed consideration should be given to the drainage requirements of the ballast and formation and future maintenance of track drainage.

NOTE: See NR/SP/OHS/069 Lineside facilities for personnel safety.

6.3 Ballast

6.3.1 General

Sufficient depth and width of ballast should be specified to:

- a) distribute dead and live loads to the formation, subgrade and structures without overstressing them;