

Category 1 Standard

S1176

Inspection and repair to reduce the risk of derailment at switches



**Please read the Written Notices
attached to this standard**

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1 Purpose

- 1.1 This standard describes the inspection regime, monitoring procedures, immediate actions and essential maintenance to be undertaken at switches to reduce the risk of derailment.
- 1.2 It identifies the particular derailment hazards associated with switch wear and damage and the remedial measures necessary.

2 Scope

- 2.1 This standard applies to all track in running lines, depots and sidings.
- 2.2 This standard applies to all switches in London Underground's permanent way that may at any time or circumstance be used in a facing direction (except as noted below).
- 2.3 This standard shall be applied to all types of switch machining in both bullhead and flatbottom rail sections, except that the switch wear gauge may be used only on chamfered and undercut switches.
- 2.4 The requirements do not apply to:
 - a) the switch half sets of trap points which are in the open position for ordinary running
 - b) switch diamonds (moveable angles)
 - c) adjustment switches.

3 Requirements

3.1 Background

- 3.1.1 All switches used in the facing direction require robust inspection procedures that drive timely maintenance intervention that will:
 - minimise the risk of derailment
 - maximise the asset life
 - deliver good operational availability.
- 3.1.2 Reviews of derailments at facing switches have highlighted a number of switch component profiles and track maintenance conditions which can create a high risk of derailment .
- 3.1.3 The main features of such conditions are described in this standard. However, these features should not be taken as exhaustive, nor do the descriptions and references to general maintenance requirements illustrate every feature to look for.

3.2 Derailment hazards – overview

- 3.2.1 The condition and profile of the rail components at switches greatly affect the derailment risk. Five particular derailment hazards have been identified:-
 - a) Hazard 1: sideworn stock rail associated with a little used switch rail



- b) Hazard 2: stock rail and switch rail both sideworn
- c) Hazard 3: stock rail headwear associated with a less headworn switch
- d) Hazard 4: switch rail damage
- e) Hazard 5: switch rail with a sharp gauge corner profile.

3.2.2 Factors that increase risk include:

- a) alignments where the wheel flange runs in hard contact with the high or outer rail including:
 - I. similar flexure turnouts
 - II. shorter switches (A to D)
 - III. curved junctionwork laid without cant
- b) high usage such that wear rates are high and geometry can deteriorate quickly
- c) chamfered or undercut switches used in both a facing and trailing direction (e.g. terminal platforms and reversible lines) where high stock rail wear results
- d) switches that have been secured out of use and returned to service
- e) locations lacking lubrication of the gauge face of the switch rail where it is subject to high wheel flange loading
- f) switches used only rarely in a facing direction (particularly risk for Hazard 1)
- g) areas of generally poor track geometry and component condition. In particular conditions that may reduce vertical loading (twist) or increase lateral loading (alignment) need to be identified and corrected.

3.3 'Tell tale' signs of derailment risk

3.3.1 'Tell tale' signs of the increased risk of derailment can be observed on the switch and stock rails, as a result of the interaction with passing wheels. The early identification of these signs is essential if the safety of the permanent way is to be maintained.

3.3.2 Early intervention and corrective action will minimise risk and prolong the life of the components.

3.3.3 There are two fundamental circumstances that must be understood in the identification of derailment risk:

- The switch rail associated with the diverging path through a turnout will generally be the most critical
- The risk is greatest for a wheel, approaching the switch rail, when it is in flange contact with the stock rail. Switch rails having an associated stock rail which is sideworn present an increased risk.

3.3.4 'Tell tale' signs for particular hazards can be identified as follows:-



Hazard No.	Details	Tell tale signs
1	Sideworn stock rail associated with a little used switch rail	• The switch tip projects above the bottom of the sidewear scar • The switch tip has been struck by wheels • The switch tip has been deformed by wheels into the sideworn stock rail
2	Stock rail and switch rail both sideworn	• The switch rail may be more worn and display a flatter sidewear angle than the stock rail • The wheels have formed a ramp on the switch rail • Markings have been left by the wheel flange as it has begun to climb the switch rail and then slipped back
3	Stock rail headwear associated with a less headworn switch	• The switch tip has been struck by wheels
4	Switch rail damage	• Lipping is present on the gauge face of the stock rail and/or the back edge of the switch rail • There is evidence of: * horizontal longitudinal cracking under lipping on the switch rail; * small pieces of metal starting to lift out of the switch rail; * numerous pieces having broken out of the switch rail; * hogged switch rails associated with lipped components
5	Switch rail with a sharp gauge corner profile	• Associated with austenitic manganese and mill heat treated rail steels, but may be present in newly-ground rails of all steel types. • Any profile forming a noticeable edge or faceted surface at the gauge corner • Dust / shavings of steel in proximity of switch • Bright marking indicating wheel contact with a sharp radius

3.4 Inspection gauges and their use

3.4.1 Approved gauges

The following gauges shall be used when inspecting switches:

• Track gauge with P8 wheel profiles	e.g. Part No. 039/028311 or 12	See clauses 3.4.2 and 7.1
• Switch wear gauge	RE/PW/429 Part No. 57/048778	See clauses 3.4.3 and 7.2
• Metric stepped gauge for use with switch wear gauge	RE/PW/431 Part No. 57/075502	See clause 7.3
• NR4 plain rail sidewear gauge	RE/PW/444 Part No. 57/048899	See clauses 3.4.4 and 7.4
• S&C maintenance gauge	RE/PW/425 Part No. 57/075499	See clauses 3.4.5 and 7.5
• Switch rail radius gauge	RE/PW/430 Part No. 57/075501	See clauses 3.4.6 and 7.6

Before use, all gauges shall be checked visually for damage and wear and that there is a valid calibration certificate.

3.4.2 Track gauge with P8 wheel profiles (TGP8)

This gauge shall be used during routine Supervisors' and Track Maintenance Engineers' visual track inspection.

It is used to visualise the wheel flange path along a switch rail and to determine if wear or damage is leading to conditions that require a detailed inspection in accordance with this specification, that is where contact between switch rail and wheel flange is below the 60° line.

This gauge can be used on all types of switches; due allowance for switch rail hog must be made.

See clause 7.1 for illustration.

3.4.3 Switch wear gauge

This gauge is designed for two specific checks during switch inspection and shall be used as follows:

Gauge 1 To identify the relationship between the running surface of the stock rail and the top surface of the switch rail at a specified position back from the switch tip.

Gauge 2 To identify whether the depth of any damage or chipping of the running surface to the switch rail is safe or otherwise.

The switch wear gauge can be used only on chamfered and undercut switches; due allowance for switch rail hog must be made.

See clauses 7.2 and 7.3 for illustrations.

3.4.4 NR4 plain rail sidewear gauge

The NR4 plain rail sidewear gauge shall be used to measure the sidewear on the stock rail front and at a specified position.

See clause 7.4 for details of the gauge and its use.

3.4.5 S&C maintenance gauge or Switch rail radius gauge

Either of these gauges shall be used to identify the profile of the gauge corner of the switch rails manufactured from Mill Heat Treated (MHT) steel or Austenitic Manganese Steel (AMS).

See clauses 7.5 and 7.6 for illustrations.

3.5 Routine visual inspection

3.5.1 The PM4 Inspector's visual inspection shall be the basis for determining whether the detailed inspection procedures set out in this standard are to be applied.

3.5.2 During the PM4 Inspector's visual track inspection all switches shall be visually examined in both open and closed positions for the damage described in this standard and hence increased derailment risk. Particular attention shall be paid to:

- a) the tell tale signs as detailed above
- b) any pieces broken from the top or toe of the switch rail
- c) signs of new, changed or aggressive wear patterns
- d) wear on recently ground switches
- e) state of lubrication of the switch and stock gauge face



f) general track condition.

3.5.3 As part of the PM4 inspection a check shall be made throughout the affected switch for contact between the P8 wheel profile and switch rail below 60° line. In some circumstances this may require that the switches be checked in both normal and reverse positions.

3.5.4 The critical area for inspection is where the wheel flanges first make contact with the switch rail in facing movements:

- For new switches this will occur in the first 2000mm from the toe;
- For switches that have already been ground or weld-repaired the point where the wheel flange first makes contact with the switch rail in facing movements will vary.

If any contact occurs between the switch rail and P8 profile below the 60° line on the P8 profile (see clause 7.1 for illustration) in either or both of the following circumstances:

- over a length of 200mm or more within the switch rail machining;
- associated with switch rail damage 200mm or more long (see clause 6.3 for illustrations)

Then:

- an approved lubricant shall be applied immediately (before the next facing move) to the gauge face of the affected switch to reduce the risk of flange climbing;
- a detailed inspection in accordance with this standard shall be carried out within 36 hours;
- the results of the inspection shall be acted upon in accordance with this specification;

Or

- arrangements shall be made to ban any facing movement involving the associated switch rail until the inspection and assessment has been completed and appropriate action implemented.

3.5.5 The PM4 Inspector shall record details of any defects found, actions taken and actions required in his track inspection report.

3.6 Frequency of inspection

3.6.1 Switches manufactured from pearlitic rail steels

For switches manufactured from pearlitic rail steels, e.g. grade R220 or R260 as defined in BS EN 13674-2:

- The PM4 visual inspection shall be carried out at the frequency specified in standard S1158;
- When required by the PM4 visual inspection, detailed inspections as described in this standard shall be carried out at a frequency commensurate with risk and documented wear rates. The interval for these inspections shall be a maximum of 12 weeks unless supported by a

risk assessment prepared by the PM4 Inspector and approved by the Senior Track Manager.

3.6.2 Switches manufactured from austenitic manganese or mill heat treated (R350HT) steels

No such switches exist in LU's permanent way but should they be used in the future they shall, in addition to those inspections required for switches manufactured from pearlitic rail steel, be subject to a special inspection of the switch rail gauge corner profile (Hazard 5) at the following intervals:

Time after installation, weld repairs or grinding of lipping which failed on inspection for Hazard 5	Inspection Frequency	Maximum interval between inspections
0 - 1 month	7 days	8 days
1 - 6 months	28 days	31 days
6 - 18 months	13 weeks	15 weeks
After 18 months	6 months	7 months

3.7 Inspection procedures and actions for derailment hazards – general requirements

- 3.7.1 Five particular derailment hazards are described in this section, together with the respective inspection procedures and minimum actions.
- 3.7.2 The switches shall be inspected in both the normal and reversed positions. Contact with the signaller, or person with controlling authority, will therefore be required. Open switches should be scotched in order to prevent trapping of fingers.
- 3.7.3 Grease and accumulated residue shall be cleaned off the rails to the extent required for assessment of lipping and switch blade damage and wear and also to permit correct readings to be obtained from the gauges.
- 3.7.4 All repairs affecting the contact surface between the switch rail and the wheel flange shall be carried out in such a manner as to provide a flange contact angle of greater than 60°.
- 3.7.5 Derailment hazards 1 to 4 are described with the assumption that the underside of the switch rail will be seated on the slide baseplates or chairs. In all inspections the seating condition shall be checked and any clearance recorded. This clearance shall be taken into account when the inspection details are established and the failure criteria applied. The clearance shall also be taken into account in any subsequent action.
- 3.7.6 The actions set out in this specification are intended to make switches that have become excessively worn safe for the passage of trains however experience shows that taking action only in the event of failure, or imminent failure, to meet this specification will not be an effective way to manage switch wear whereas **regular planned removal of lipping, early repair of damage and regular re-building of wear by welding will prolong switch life.**

Note: As an example the heavy grinding to remove a Hazard 2 or Hazard 4 failure will greatly reduce the cross section of the switch (thus making it vulnerable to damage) and move the point at which the wheel flange contacts the switch rail back towards the switch heel increasing the angle of attack (and hence increasing the wear rate). The result of this will be only a relative short period of use before the switch rail once again fails due to wear.

- 3.7.7 Where a switch is considered potentially suitable for weld repair an assessment shall be carried out by an appropriately qualified person and recorded on a Switches and crossings welding assessment / replacement form.

- 3.7.8 All weld repairs shall be undertaken to the requirements of T0436.
- 3.7.9 It is very important that the detailed inspections are carried out fully and an assessment made of the combined results before any remedial treatment is considered; this will identify all potential failure modes.
- 3.7.10 When inspection (detailed or visual) reveals sub-standard conditions such that the switches will fail the criteria in this standard, or are likely to fail if remedial work is not carried out (for example the removal of lipping or improving lubrication), then the Local Track Manager shall plan the necessary interventions.
- 3.7.11 If the inspection reveals severely deficient switch rail conditions then mitigating actions must be discussed with the Maintenance Assurance Engineer and all options considered, including banning facing moves.
- 3.7.12 In preparing the detailed scope of work the Local Track Manager shall consult, as necessary, the:
- a) track inspection records and workbank (for example Ellipse) – for any associated work required
 - b) current detailed inspection reports – for latest detail of the switches
 - c) records of previous repair work to the switches concerned
 - d) welding organisation – for expert advice on the practicability of weld repair including estimates of time required
 - e) rail grinding organisation – for expert advice on the practicability of remedial grinding including removal of defects (for example RCF) and estimates of the time required
- 3.7.13 The proposed work package shall be endorsed by the Track Asset Manager before any work is planned in detail or carried out.
- 3.7.14 Where weld repairs are to be carried out details shall be recorded.
- 3.7.15 Where grinding repairs are carried out details shall be recorded.

3.8 Detailed inspection procedures and actions for the particular derailment hazards

Note: In sections 3.8.1 to 3.8.5, distances over which certain inspections are to be made are given in terms of letters A to K, which are defined in the applicable section. These letters are retained from Network Rail standard NR/L2/TRK/0053, on which this standard is closely based, so that common training material may be used.

3.8.1 Derailment hazard 1 - Sideworn stock rail associated with a little used switch rail

3.8.1.1 Equipment required

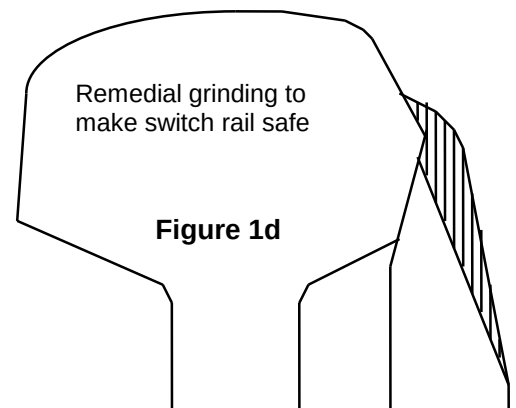
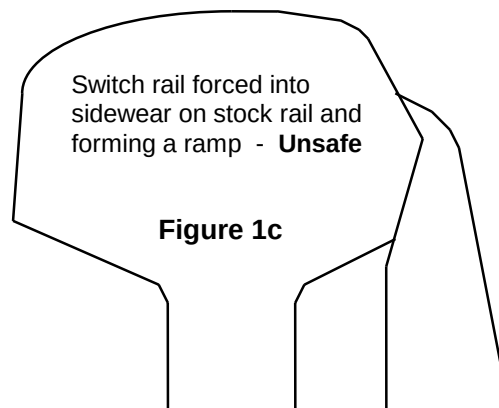
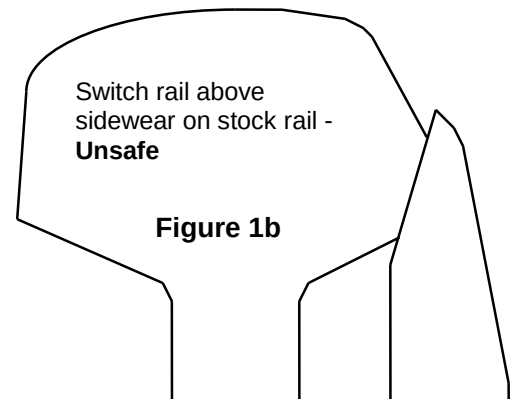
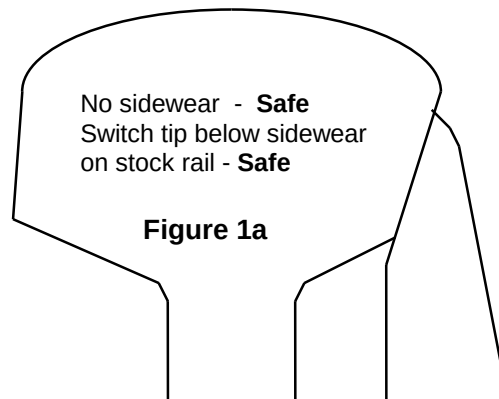
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|-------------------------------|-------------------------|
| Metric stepped gauge | (Clause 7.3) |
| NR4 Plain rail sidewear gauge | (Clauses 3.4.4 and 7.4) |

3.8.1.2 Description

Figure 1a shows an unworn switch rail and stock rail closed together.

A high risk situation can arise if stock rail sidewear is allowed to reach a condition where the tip of the switch rail projects above the bottom of the sidewear scar (Figure 1b).

Flange contact with such a switch rail can deform the tip of the switch rail into the sidewear on the stock rail (Figure 1c). This reduces the contact angle between switch rail and flange to a point where flange climb is likely, and provides a ledge along which a wheel flange can run. The problem is more likely to occur at sites where facing train movements through the diverging path of the turnout are less than half those on the through line.



3.8.1.3 Inspection

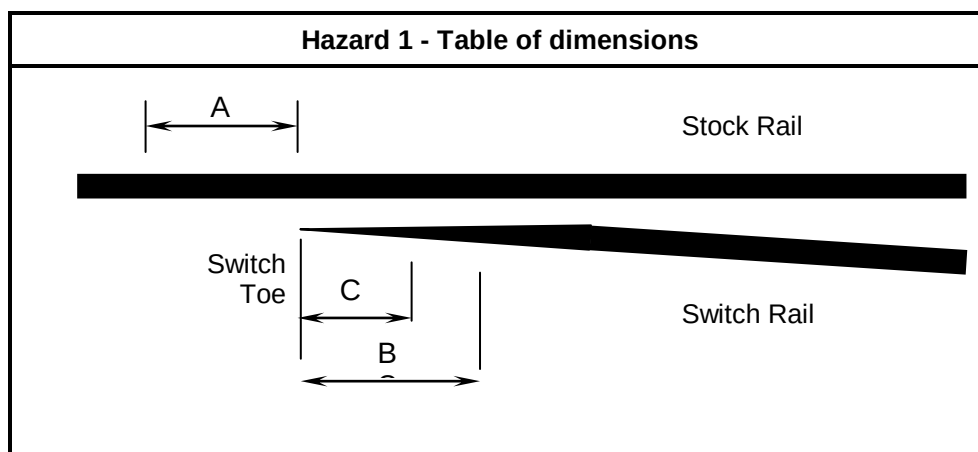
This inspection shall be carried out with the switch rail closed against the stock rail.

The switch rail seating condition shall be checked and recorded.

The sidewear on the stock rail front shall be checked with the plain rail sidewear gauge between the switch toe and a distance of A mm along the stock rail front. The worst sidewear reading (lowest number) in this length is recorded and used to determine the action required (see Hazard 1 table below).

If there is little or no wear on the first B mm of the switch rail when compared to the wear on the stock rail a check shall be made to establish whether, within the first C mm, the top of the switch rail is level with or projects above the bottom of the sidewear scar on the stock rail (see Hazard 1 table below).

If within this length the top of the switch rail is found to be level with or projects above the bottom of the sidewear scar on the stock rail, it fails the inspection.



Switch type	A (mm) Measure Sidewear	B (mm) Look for sidewear on switch and stock rail	C (mm) Check if switch rail projects above sidewear scar
All	1000	500	200

3.8.1.4 Action required

Action 1.1 - If at any time the top of the switch rail, within the first B mm from the toe, is found to be level with or to project above the bottom of the sidewear scar on the stock rail then within 7 days:

- the running surface of the switch rail shall be ground and reprofiled until the tip is 2mm below the sidewear on the stock rail (see Figure 1d above).
- the gauge corner radius profile shall be ground over the same length until it passes an inspection using the S&C maintenance gauge or the switch rail radius gauge.

Or

- arrangements shall be made to prohibit any facing movement involving the associated switch rail until either the grinding has been carried out or the half set of switches is replaced.

The transition from the newly ground rail to the adjoining un-ground rail will be at a maximum rate of no greater than 1 in 600 (for example a grinding depth of 2mm will be run out over 1200mm) and there must be a gradual transition of the newly-ground rail head profile to the adjacent un-ground profile over this length. The ground area (including transition) will be checked using a track gauge with P8 wheel profiles to confirm that the wheel contact angle is satisfactory throughout the length.

Action 1.2 - If a sidewear reading of step 10 to 12 is obtained at any point within the A mm distance from the switch toe:

- the frequency of the detailed inspection shall be reviewed and if necessary increased considering:
 - the rate of sidewear development
 - the track category
 - the frequency of Supervisors' visual inspections
- the lubrication regime will be reviewed and improved if necessary
- the condition of the switches shall be monitored for further wear and any subsequent deterioration shall be treated by grinding as detailed above or by weld repair of the sidewear in accordance with T0436.

Action 1.3 - If a sidewear reading of step 7 to 9 is obtained:

- a replacement half set of switches shall be ordered
- the frequency of the detailed inspection shall be increased to monthly
- the condition of the switches monitored for further wear and any subsequent deterioration shall be treated by grinding as detailed above.
- arrangements shall be made to replace the half set of switches before the sidewear reaches step 6 based on recorded wear rates.

Action 1.4 - If a sidewear reading of step 6 or lower is obtained arrangements shall be made to immediately ban facing movement involving the associated switch rail. This prohibition shall remain in place until the half set of switches is replaced.

3.8.2 Derailment hazard 2 - Stock rail and switch rail both sideworn

3.8.2.1 Equipment required

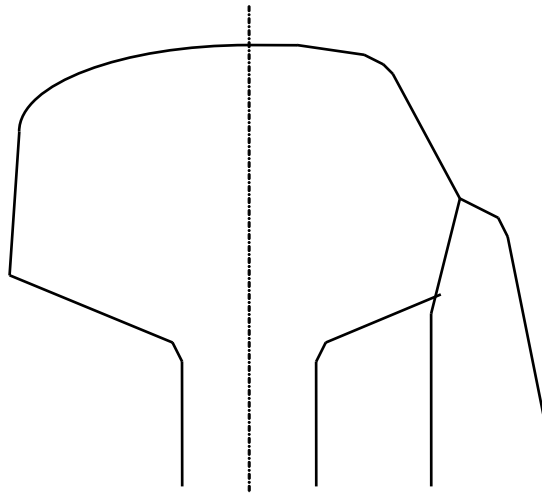
Track gauge with P8 wheel profiles	(Clauses 3.4.2 and 7.1)
Switch wear gauge – Gauge 2	(Clauses 3.4.3 and 7.2)
Metric stepped gauge	(Clause 7.3)
NR4 Plain rail sidewear gauge	(Clauses 3.4.4 and 7.4)

3.8.2.2 Description

Locations exist where the stock rail and the switch rail are both sideworn (see Figure 2a below). This feature can occur naturally when the through line is curved, and the turnout is heavily used (for example in a similar flexure turnout), it is unlikely to occur where the through line is straight.

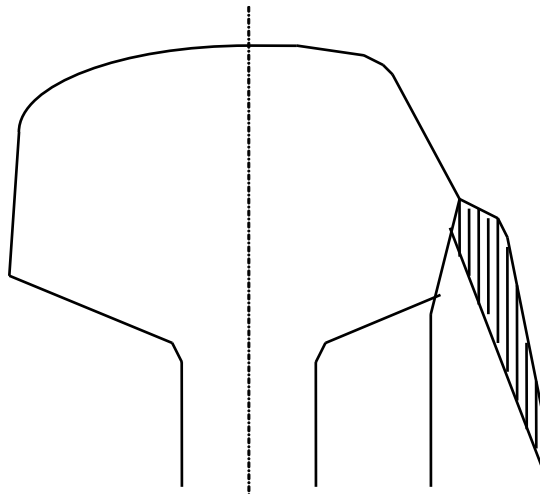
It can also occur when a damaged switch rail is left in service and traffic "smoothes out" the damage.

The high risk feature in this situation is the sudden change of flange contact angle over the first part of the switch rail where in facing movements the wheelsets are steered by the switch rail. Evidence of this sudden change can be seen by the marking left by the wheel flange as it has begun to climb the switch rail and then slipped back.



Stock rail and switch rail both sideworn. Angle of sidewear on the switch rail flatter than that on the stock rail and will make contact with the TGP8 below the 60° line

Figure 2a



Switch rail made safe by remedial grinding to produce a steeper angle on the switch rail than the sidewear angle on the stock rail and switch top is reduced below the sidewear scar on the stock rail.

Figure 2b

3.8.2.3 Inspection

This inspection is necessary on all P&C where the through route is curved (similar or contra-flexure turnouts) or where the through route is straight and sidewear of 10 or less is measured on the stock rail front within F mm of the toe (see Hazard 2 table below).

Inspection shall be carried out as follows:

- The switch toe seating condition and any switch rail hogging shall be checked and recorded.
- Gauge 2 shall be used to check whether it passes over the top of the undamaged switch rail at any point. If it does then the P8 contact shall be checked over the whole length of the planning.
- With the switch closed against the stock rail the track gauge with P8 wheel profiles shall be used to check the flange contact angle is at or above the 60° line on the switch rail for D mm from the switch toe (see Hazard 2 table below).
- Where the switch rail is sideworn within E mm of the tip, the sidewear on the stock rail front adjacent to the tip shall be checked with a plain line sidewear gauge with the switch in the open position (see Hazard 2 table below).