A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT/ RAIL NETWORK

BBG5568

Testing parameters for turnout monitoring and approval

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Date:			8 June 2015

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Contents

1 Document scope

This document entails a breakdown of all turnout parameters to be tested during performance testing for the purpose of turnout approval, as well as research and development.

2 Document limitations

The parameters listed in this section form the basis on which any turnout will be evaluated but may be amended to best suit the needs of Transnet Freight Rail.

3 Test parameters

During the in-track performance testing various parameters will be tested for technical suitability and compliance to specifications. These parameters are selected based on the existing specifications for turnouts and knowledge with regards to turnout performance and consists of the categories with fields as indicated in the diagram below. In addition all the fields contained within the headings are discussed in subsequent sections.

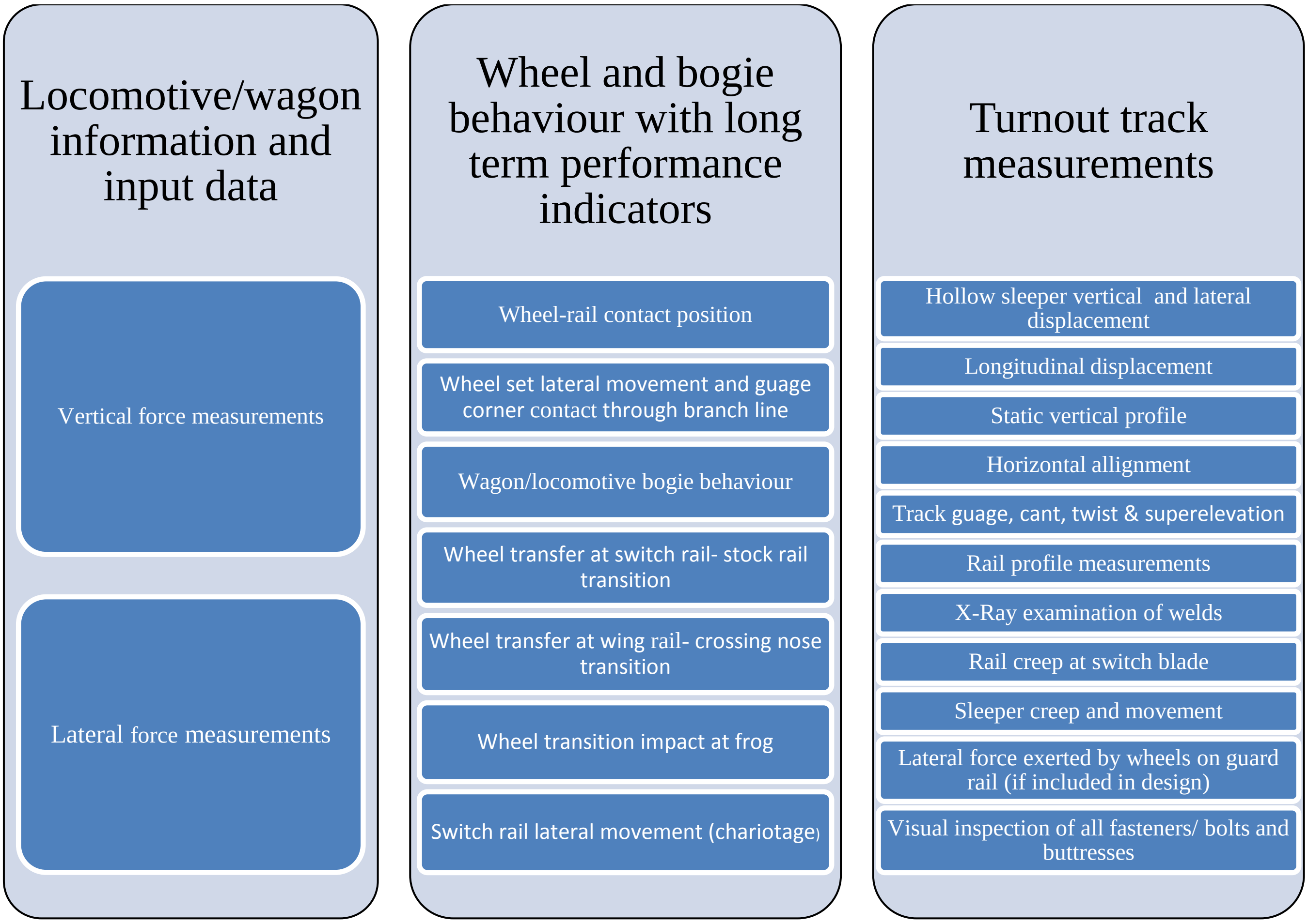

Figure 1: Testing parameters summary

3.1 Locomotive/wagon information and input data

3.1.1 Vertical force measurements

3.1.1.1 Test scope

Vertical force measurements will be taken at multiple stations to identify the location of the individual wheels, define parameters such as axle load, skew loading, and flat wheels which may influence on other measured parameters. Vertical induced forces are used to identify and correlate measured parameters (lateral force) with specific wheels. The measured vertical forces are dependent on the locomotive/ wagon characteristics and will be used to distinguish rolling stock.

3.1.1.2 Testing methodology

Vertical forces will be measured by pasting strain gauges to the web of the rail. Amplifiers are connected to the strain gauges that measure the change in length of the gauge. The gauges are calibrated for an input range using special calibration equipment. The vertical force will be measured for every wheel that crosses the test point and will be continuously measured for all the wheels of both locomotives and wagons.

3.1.1.3 Expected outcome

Vertical force measurements will be measured and recorded that correspond with the induced dynamic vertical load, the product of the axle load and the Dynamic Amplification Factor (DAF). Outliers will be identified and will be indicative of wheel defects such as flat-wheels.

The lateral force data will be analysed and processed for further statistical investigations as described in further sections.

3.1.1.4 Test location

The vertical force will be measured at 5 locations as listed in the table and indicated in the figure below.

Table 1: Test Station layout vertical force

Station	Description
V1	SRJ of turnout, Left rail and right rail
V2	EOS, left rail and right rail, main line
V3	EOS, left rail and right rail, branch line
V4	Midway on closure panel, left rail and right

	rail, main line
V5	Midway on closure panel, left rail and right rail, branch line

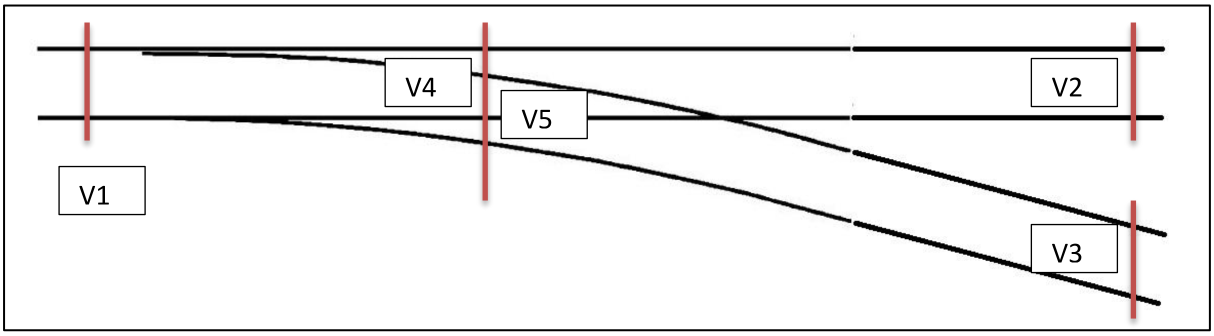

Figure 2: Test station layout vertical forces

3.1.2 Lateral force measurements

3.1.2.1 Test scope

Lateral forces will be measured at various locations along the turnout on both main and branch lines. The emphasis will however be placed on the branch line as the magnitude of lateral forces is expected to be higher in the curve due to uncompensated centrifugal acceleration of the vehicle compared to main line lateral forces as the result of hunting, skew bogies or bogie instability.

Single measurements of lateral forces will be measured on the high leg of the branch line at 3 locations along the curve lead on the branch line to investigate the lateral forces due to the uncompensated centrifugal acceleration.

3.1.2.2 Testing methodology

Similar to Vertical force measurements, lateral forces will be measured by pasting strain gauges to the web of the rail. Amplifiers are connected to the gauges that measure the change in length of the gauge. The gauges are calibrated for an input range using special calibration equipment. The lateral force will be measured for every wheel that crosses the test point and will be continuously measured for all the wheels of both locomotives and wagons.

3.1.2.3 Expected outcome

The induced lateral forces on main and branch line will be measured and compared to the allowable lateral forces stated in the design limits. The lateral forces will be evaluated for the average of the sample axles measured.

The lateral force data will be analysed and processed for further investigations as described in further sections.

3.1.2.4 Test location

The lateral forces will be measured at 7 locations as listed in the table and indicated in the figure below.

Table 2: Test station layout lateral forces

Station	Description
L1	SRJ of turnout, Left rail and right rail
L2	EOS, left rail and right rail, main line
L3	EOS, left rail and right rail, branch line
L4	Midway on closure panel, left rail and right rail, main line
L5	Midway on closure panel, left rail and right rail, branch line
L6	Start of closure panel, curve lead, left rail
L7	End of tangent curve/ start of crossing, curve lead, left rail

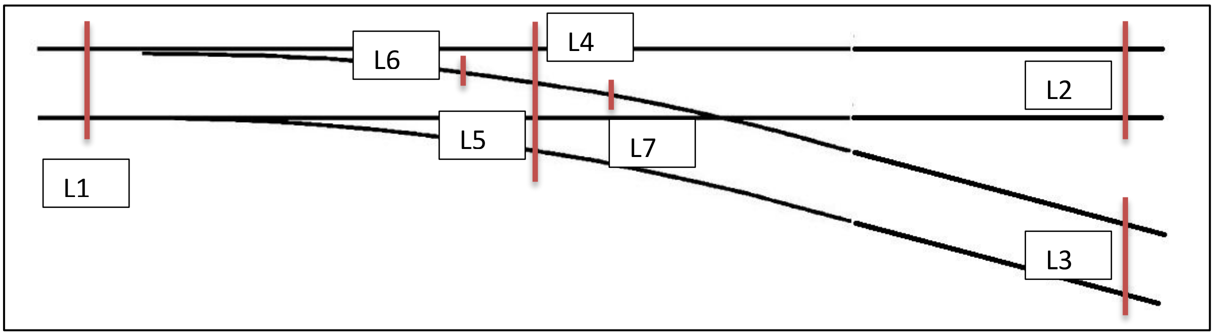

Figure 3: Test station layout lateral forces

3.2 Wheel and bogie behaviour with long term performance indicators

3.2.1 Wheel-rail contact position

3.2.1.1 Test scope

Wheel contact position will be recorded to investigate the running position on both tread of the wheel and the head of the rail. This will be used in conjunction with lateral force measurements to predict bogie behaviour and optimize wheel-rail contact through the main and branch line of the turnout.

The results from these measurements will be used to identify possible cases of poor wheel-rail interaction; irregular wheel set movements and high stress areas. These measurements will provide information on the long term behaviour of the turnouts and the necessity for rail profile correction in excess of routine maintenance.

These measurements may also serve as input for further computer-based simulations in an attempt to optimize wheel-rail contact in future.

3.2.1.2 Testing methodology

The contact position will be recorded through visual inspection of the contact patch at 500mm increments after each train has passed. In order to increase visibility of the contact band, a thin layer of paint will be applied to the surface of the rail, and typically at the point of contact the layer of paint is removed.

3.2.1.3 Expected outcome

The contact position will provide information on the location of contact of the passing wheels. Any sudden movement or change in contact position can be picked up and will provide information wheel and bogie behaviour over specific regions of the turnouts and will also provide guidance to possible wheel-rail interaction deficiencies.

3.2.1.4 Test location

As mentioned the wheel-rail contact position will be measured at 500mm increments throughout the length of the turnout on both main and branch lines.

3.2.2 Wheel set lateral movement, gauge corner contact and angle of attack through branch line

3.2.2.1 Test scope

Lateral movement of the wheels through the branch line will be measured at two major locations to investigate wheel set steering and the presence of wheel flange contact on the switch and stock rail through the curve lead.

During this investigation the wheel orientation and angle of attack will be measured to define the steering capabilities of rolling stock through the branch line of the turnout.

These measurements will also be used in conjunction with wheel contact position measurements to investigate wheel-rail interaction and the optimization of the running surface.

3.2.2.2 Testing methodology

Infrared lasers will be installed at two locations along the outer leg of the branch line that is used to measure the distance between the rail surface 14mm below the crown of the rail and the back of the wheel. With some calculation the distance between the wheel flange and the rail surface can be determined. This measurement will be taken for all wheels that pass this point and will be used to define the wheel path more accurately.

The second part of this test will be to determine the angle of attack of each wheel. This will be investigated by measuring the distance between the a fixed reference point and the back of the wheel at two locations approximately 200mm apart. Through some calculation the angle of attack of the measured wheel can be calculated for each wheel.

3.2.2.3 Expected outcome

The results from the test conducted will provide vital information on the wheel path through the branch line and will also provide information on the behaviour of the wheel in response to the designed curve.

3.2.2.4 Test location

The location for the installation of the infrared lasers will be as listed in the table and figure below.

Table 3: Test location layout laser

Station	Description
Laser 1	Tip of points switch rail, branch line,
Laser 2	Tip of points switch rail, branch line, laser 1+200mm
Laser 3	Mid blade of points switch rail, branch line
Laser 4	Mid blade of points switch rail, branch line laser 3 +200mm

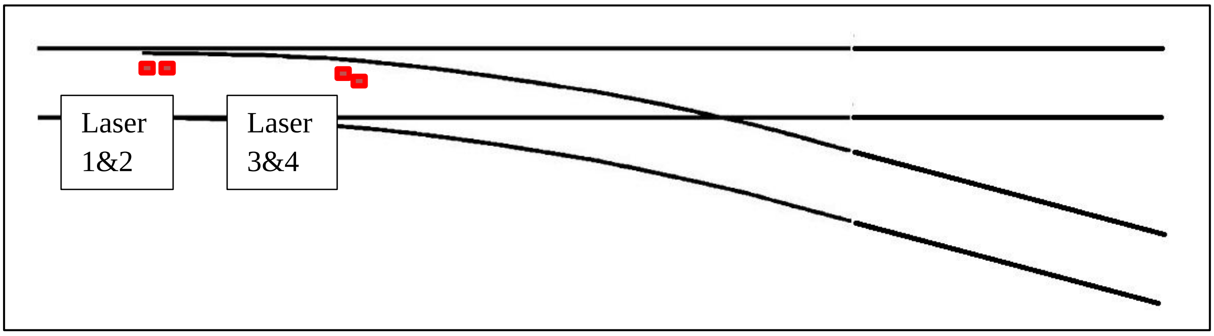

Figure 4: Test location layout lasers on branch line

3.2.3 Wagon/locomotive bogie behaviour

3.2.3.1 Test scope

The results from the measured forces will be used to analyse the movement and behaviour of the bogies through the main and branch line of the turnout and may be used to identify irregular movement and identify patterns that will require further investigation.

3.2.3.2 Testing methodology

There will be no physical testing conducted and all data used for this investigation will be gathered from other tests conducted and discussed previously. Data to be used for this investigation includes vertical forces, lateral forces and lasers.

3.2.3.3 Test location

No physical testing to be conducted

3.2.4 Wheel transfer zone at switch-stock rail transition

3.2.4.1 Test scope

Measurement and investigation into the wheel transfer zone between switch rail and stock rail as these are normally areas where high rolling contact fatigue occurs.

3.2.4.2 Testing methodology

Rail sections will be measured over the length of the turnout where transition will occur. The contact will be recorded and investigated by coating the rail with a thin layer of paint that will be removed upon contact.

3.2.4.3 Expected outcome

Rail section measurements will be taken during installation of the turnout and contact measurements will be taken for all applicable rolling stock.

The measured results will serve as input for computer based simulations that look at the contact zones and the resultant contact stresses.

3.2.4.4 Test location

The measurements will be taken at location as indicated in the figure below.

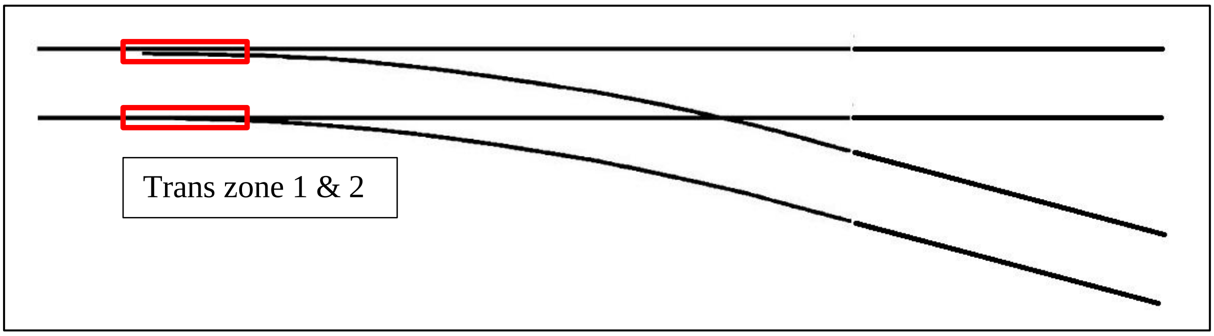

Figure 5: Test location layout for stock rail to switch rail transition measurements

3.2.5 Wheel transfer zone at wing rail-nose transition

3.2.5.1 Test scope

Measurement and investigation into the wheel transfer zone between wing rail and frog nose as these are normally areas where damage occurs under normal traffic with presence of “out-of-round wheels” or hollow-worn wheels.

3.2.5.2 Testing methodology

Rail sections will be measured over the length of the turnout where transition will occur. The contact will be recorded and investigated by coating the rail with a thin layer of paint that will be removed upon contact.

3.2.5.3 Expected outcome

Rail section measurements will be taken during installation of the turnout and contact measurements will be taken for all applicable rolling stock.

The measured results will serve as input for computer based simulations that look at the contact zones and the resultant contact stresses.

3.2.5.4 Test location

The measurements will be taken at location as indicated in the figure below.

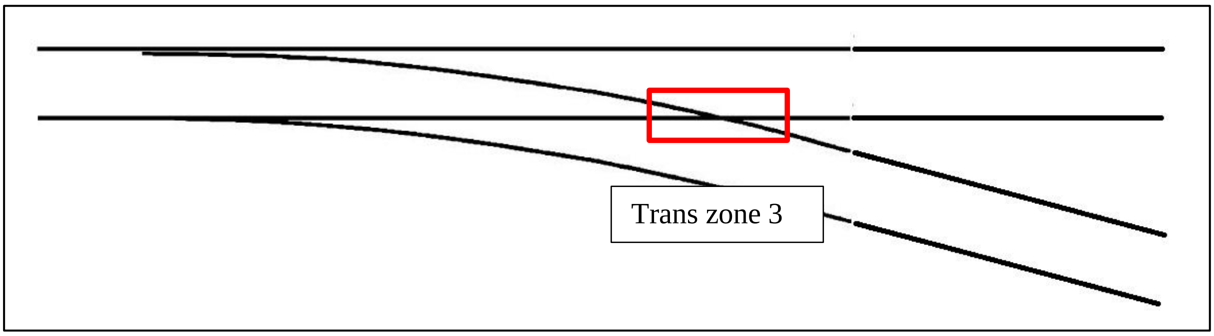

Figure 6: Test station layout for wing rail to nose transition measurements

3.2.6 Wheel transition impact at frog

3.2.6.1 Test scope

Impact forces on the nose of the frog will be measured for various speeds to provide indicators for possible damage and plastic deformation. This information may also be used to optimise the design of the frog nose and reduce this impact.

3.2.6.2 Testing methodology

Accelerometers will be installed on the crossing chassis (rail bound/mono block) within close proximity of the point of impact. The acceleration will be measured continuously for all wheels and analysis of the impacts will be done to calculate the induced force and resultant stresses.

3.2.6.3 Expected outcome

Impact forces calculated for all wheels using the data gathered from the accelerometers. The results will guide the optimization of the wheel transfer region and reduce wheel impacts. High impacts will result in poor performance of crossing and high wear of the crossing nose and wing rails.

3.2.6.4 Test location

The test equipment will be installed on the rail bound or mono-block crossing chassis at the location as indicated in the figure below.

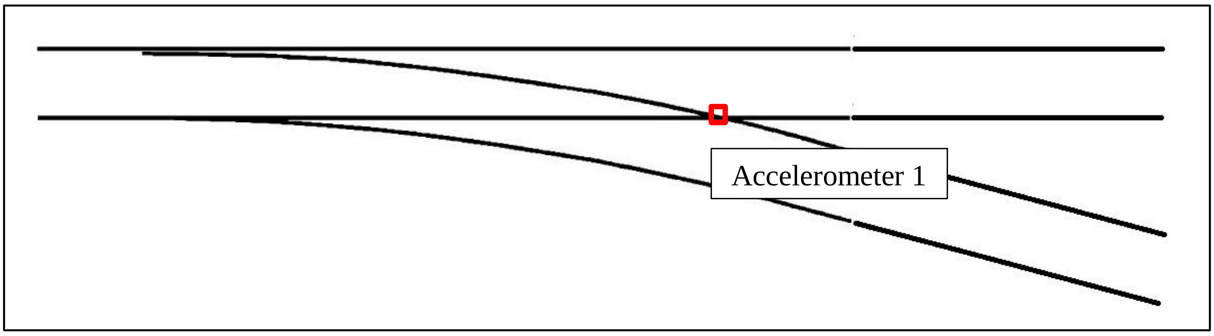

Figure 7: Test station layout for wheel impact measurements

3.2.7 Switch rail lateral movement (chariotage)

3.2.7.1 Test scope

The mechanism of chariotage is the movement and cyclic opening of the blade at the tip of the nose when a lateral force is applied by other wheels away from the tip of the blade. This will be measured by utilizing lasers installed at the tip of the switch rail. The lateral movement will be continuously measured as a lateral force is applied along the length of the switch rail.

3.2.7.2 Testing methodology

Lateral movement of the switch rail tip will be measured by installing Infrared lasers at selected position along the switch rail specifically at the tip of the switch rail and mid-blade.

3.2.7.3 Expected outcome

The results from the laser measurements will be used to calculate if there is any movement/ cyclic opening of the blade as result of lateral forces from adjacent wheels/bogies. If blade is not properly secured, there will be lateral movement of the points rail at the tip and mid-blade. If the blade is properly secured there will be very little to none lateral movement of the blade at the two measured points.

3.2.7.4 Test location

The test location for measuring the blade movement is illustrated in the figure below.

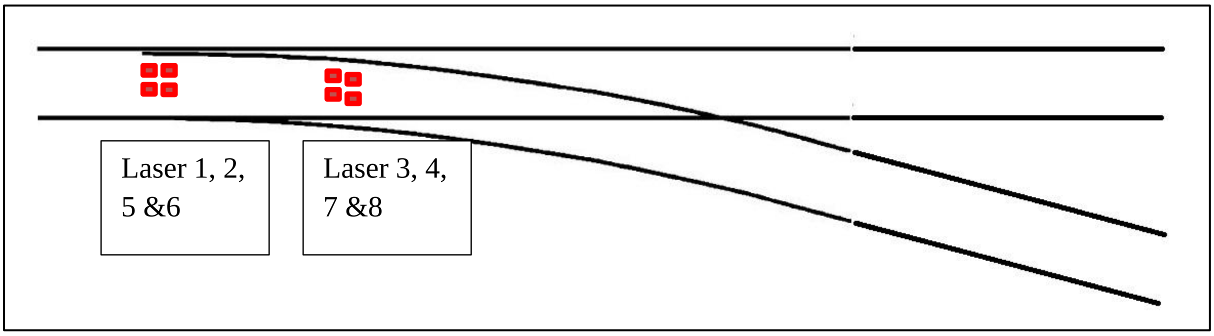

Figure 8: Test station layout for switch rail lateral movement

3.3 Turnout track measurements

3.3.1 Hollow steel sleeper vertical and lateral displacement (deflection and movement at hollow steel sleeper)

3.3.1.1 Test scope

The vertical displacement of the hollow steel sleepers and subsequent bending of the rail must be measured during passage of trains at various intervals between tamping cycles.

This investigation will yield long term results when measured over life cycle of turnout and this test may serve as benchmark on newly good ballast and formation condition.

3.3.1.2 Testing methodology

In order to continuously measure the dynamic vertical deflection of hollow steel sleepers, LVDT's will be installed in the vertical direction on one of the edges of the hollow steel sleeper. The other end will be fixed to a peg that is hammered into the track formation. The peg will not move and will be the absolute reference point from which all measurements are taken.

3.3.1.3 Expected outcome

Vertical deflection will be measured as the train moves over it. Initially deflection will be large as the ballast consolidates underneath the hollow sleeper. As consolidation occurs deflection will reduce up to a point after which deflection will start to increase as result of the loss of profile and compaction underneath the hollow sleepers. The deflection at this point will increase over time if no maintenance intervention is taken.

3.3.1.4 Test location

The vertical deflection will be measured at all the hollow steel bearers which will vary between no.9, no.12 and no.20 turnouts. The location of measurement will be as indicated in the figure below.

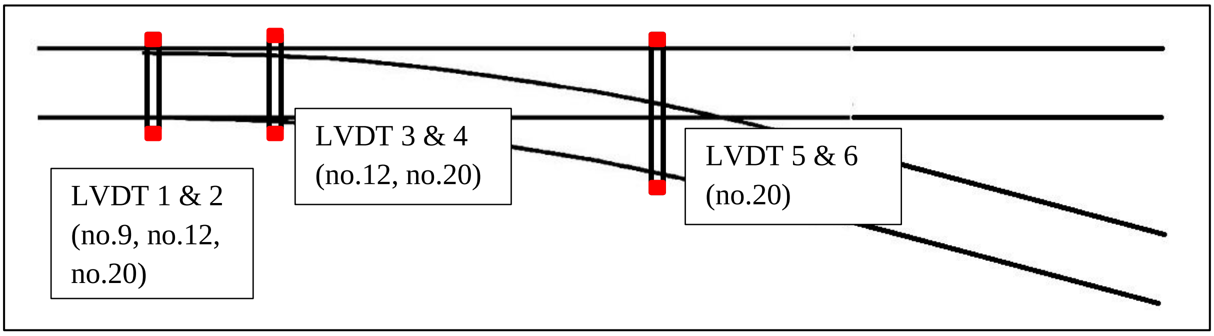

Figure 9: Test station layout hollow steel sleeper vertical and lateral displacement

3.3.2 Longitudinal displacement

3.3.2.1 Test scope

Longitudinal displacement may occur in the switch and crossing area due to thermal, acceleration and braking forces. These forces can create differential displacement between the various components of the switch or crossing.

Longitudinal displacement will be measured at two locations including the tip of the switch rail and the heel block.

3.3.2.2 Testing methodology

The differential displacement will be measured between the switch rail and the corresponding stock rail by placing a reference mark on both surfaces and measuring the gap generated over time.

Similar to switch rail displacement the displacement at the heel block area will be measured by creating reference marks on the two planes and measuring the change in displacement relative to each other over time.

3.3.2.3 Expected outcome

The measurements of the displacement between the stock rail and the switch rail are expected to vary over time as the result of thermal expansion/contraction, braking and acceleration forces. This data will provide information on the maximum relative displacement that can be expected and whether it falls within limits as specified by the points machines operational limits.

Similarly the displacement of between the adjacent stock rails will vary over time. The results from these measurements will indicate whether the turnout and its components can accommodate all the induced longitudinal forces.

3.3.2.4 Test location

The location where the longitudinal displacement will be measures is indicated in the figure below.

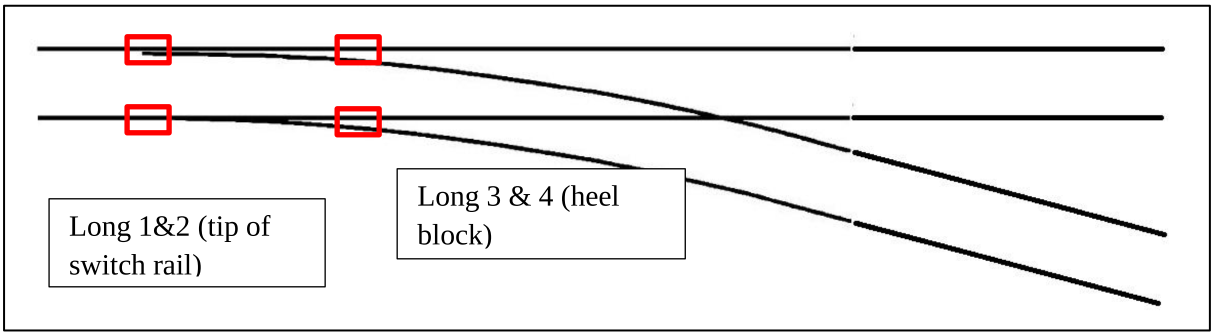

Figure 10: Test station layout for longitudinal displacement

3.3.3 Static vertical profile

3.3.3.1 Test scope

Vertical track geometry for main and branch line of the turnout. Measurements will be taken to ensure that track is correct as per Transnet Freight Rail standards and within A-standard. These measurements will be conducted at various stages of the turnout life cycle.

Any deviations from these standards may have an influence on the track measurements and may compromise the accuracy of the investigation.

3.3.3.2 Testing methodology

The static vertical profile will be measured using surveying equipment and measuring the absolute height of incremental points along the length of the turnout with reference to a fixed point.

Measurements will be taken after installation of the turnout and then at 3 monthly intervals until testing has been completed to measure the loss of vertical profile over time.

3.3.3.3 Expected outcome

The measurements will indicate the accuracy of the static vertical profile over the life cycle of the turnout. Any deviations from design heights will require maintenance work to achieve the correct vertical profile over both branch and main line of the turnout.

3.3.3.4 Test location

The static vertical profile will be taken at incremental positions along the entire length of the turnout on the main and branch line.

3.3.4 Horizontal alignment

3.3.4.1 Test scope

Horizontal alignment of track will be measured to verify conformance to design geometry. These measurements will be taken to ensure that track is correct as per Transnet Freight Rail standards. These measurements will be conducted at various stages of the turnout life cycle.

Any deviations from these standards may have an influence on the track measurements and may compromise the accuracy of the investigation.

3.3.4.2 Testing methodology

Horizontal alignment will be measured using surveying equipment that captures the location of a specific point in all three dimensions (x,y,z). The entire length of the turnout will be divided into nodes with a distance interval of approximately 1300mm.

3.3.4.3 Expected outcome

The recorded nodes will be used to plot the turnout as a set of points in a 3 dimensional environment. The data will be used to check horizontal alignment of the turnout and if deviations exceed design limits, it must be corrected by track-personnel.

3.3.4.4 Test location

The horizontal alignment will be taken at incremental positions along the entire length of the turnout on the main and branch line.

3.3.5 Track Gauge, cant, twist and super elevation measurements

3.3.5.1 Test scope

Measurements will be taken to ensure that track is correct as per Transnet Freight Rail standards and within A-standard. These measurements will be conducted at various stages of the turnout life cycle.

3.3.5.2 Testing methodology

Track gauge will be measured using a handheld tool that measures the track gauge 14mm below the crown of the rail.

In addition to this the cant and twist will be measured using surveying instrumentation.

3.3.5.3 Expected outcome

Any deviations from these standards may have an influence on the track measurements and may compromise the accuracy of the investigation. The recorded measurements will be checked and if not within standards, maintenance intervention will be taken to rectify the defects.

3.3.5.4 Test location

The track parameters will be taken at incremental positions along the entire length of the turnout on the main and branch line.

3.3.6 Rail profile measurements

3.3.6.1 Test scope

Rail profile measurements will be taken of all critical areas throughout the turnout with emphasis on the stock & switch area. These measurements will be used as reference measurements for grinding and maintenance activities and will provide input for the long term wheel-rail interaction investigation.

3.3.6.2 Testing methodology

The rail profile measurements will be taken using an electronic profile gauge that graphically portrays the rail profile at the point of measure. These measurements will be taken at points along the switch rail, stock rail, frog and closures.

3.3.6.3 Expected outcome

The rail profiles will provide the basis for all computer based simulations of wheel-rail interaction and will serve as reference point for long term wear measurements.

3.3.6.4 Test location

The rail sections will be taken at incremental positions along the entire length of the turnout on the main and branch line.

3.3.7 X-ray of welds

3.3.7.1 Test scope

Welds will be subject to non-destructive testing as per Transnet Freight Rail safety requirements. The aluminium welds will be carefully inspected to ensure structural soundness over the life cycle of the turnout.

3.3.7.2 Testing methodology

Welds will be tested in accordance with Transnet Freight Rail specifications and leading testing methodologies.

3.3.7.3 Expected outcome

X-Ray inspection of welds to be completed before commissioning of turnout. If exothermic welds fail, they will have to be cut out and cast again. Failure of aluminium welds will result in rejection of the crossing and subsequent rejection of the turnout.

Periodical testing will be done to monitor the development of cracks and rail defects in the weld region over the life cycle of the turnout.

3.3.7.4 Test location

The inspection will be conducted on all exothermic and aluminium welds within the boundaries of the turnout (SRJ to EOS)

3.3.8 Sleeper creep and movement

3.3.8.1 Test scope

Sleeper creep will be monitored over the life cycle of the turnout. Excessive creep will result in poor geometry over time and subsequent poor performance of the turnout and its components.

3.3.8.2 Testing methodology

The spacing and orientation for all the sleepers will be measured and monitored over the life cycle of the turnout. The spacing will be measured between the longitudinal centreline of two adjacent sleepers. The orientation will be measured by measuring the angle between the track centreline and the centreline of the sleeper in the longitudinal direction.

3.3.8.3 Expected outcome

Measurements of sleeper position will indicate any creep movements that may influence the track geometry. The periodical measurements will provide indication of creep forces, longitudinal resistance and rail clamping force. The measured results will also influence maintenance activities during the turnout life cycle.

3.3.8.4 Test location

Sleeper creep and movement will be measured for all sleepers including the steel hollow sleepers over the entire length of the turnout.

3.3.9 Lateral force exerted by wheels on guard rail (if included in design)

3.3.9.1 Test scope

The lateral force exerted on the guard rails will be measured. Excessive lateral forces on the guard rail and buttresses may lead to component material fatigue and ultimate failure. These measurements will only be taken on turnouts with rail bound crossings or mono-block frog design as the moveable-v does not contain any guard rails.

3.3.9.2 Testing methodology

The lateral force will be measured various locations along the guard rail (if applicable). The section of the guard rail expected to experience the highest lateral forces will be directly in line with the crossing nose. The measurement of lateral forces will be conducted by pasting strain gauges on the main body of relevant buttresses that keep the guard rail in position. Resultant strain will be measured that can be correlated to the induced lateral forces.

3.3.9.3 Expected outcome

Measured strain measurements can be correlated to induced lateral forces. These forces can be checked and compared to the limits as specified in the design.

3.3.9.4 Test location

Stress measurements will be taken at the two buttresses closest to the only be taken on turnouts with rail bound crossings or mono-block frog design as the moveable-v does not contain any guard rails.

3.3.10 Visual inspection of all fasteners/ bolts and buttresses

3.3.10.1 Test scope

Inspection of all fasteners bolts and buttresses will be done throughout the life cycle of the turnout to ensure conformance with design and possible component failures.

3.3.10.2 Testing methodology

The inspection will be a visual assessment only where the condition of the individual components will be evaluated to check for deviance from the design.

3.3.10.3 Expected outcome

A visual condition assessment of the individual components will be conducted and if any components are found to deform, deform, shift in location or behave any other way than designed, maintenance intervention to be advised.

3.3.10.4 Test location

Visual inspection of critical components will be conducted over the entire length of the turnout.

End