THE FUTURE OF TRANSPORT

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Highways England 2019 National Deflectograph Accreditation Trial

Stuart Brittain

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Contents

Executive summary

Deflectograph accreditation trials are held annually by TRL on behalf of Highways England. The objective is to monitor the performance of all Deflectographs operating on the Highways England Strategic Road Network (SRN). By examining and monitoring the results from the machines operating on specified test sections of the reference site, the performance of individual machines, and the performance of the whole UK fleet, are assessed.

The 2019 trial was held during the period 5th to 7th March 2019. The site used was the twin horizontal straights of the Horiba-MIRA proving ground. This was the twenty-fourth year in which TRL have taken full responsibility for the planning and running of the trials. Ten machines attended the trial.

The format of the 2019 trial was broadly consistent with that of recent years, comprising two scheduled days of testing and one contingency day. The 2019 trial included checks on the distance calibration which was first assessed at the 2012 trial. The first day of the trial was dedicated to static inspections and calibration checks, with the second day used for the main running trials. The contingency day was used for some additional testing.

All ten machines that participated in the 2019 accreditation trial met the mandatory requirements of the trial (wheel weight, deflection measurement and distance measurement) and can therefore be considered for approval to survey the Highways England SRN.

Nine of the ten machines achieved a high performance rating and the remaining one a medium performance rating with regards to the measurement of pavement temperature at depth.

For the 2019 trial, participants were also asked to provide air and surface temperature measurements (if they had the equipment fitted). Four machines provided air and surface temperatures. One machine achieved a high performance with regards to the measurement of surface temperature. The remaining three achieved a medium performance. All four machines achieved a high performance with regards to the measurement of air temperature (judged against the same criteria as used for assessing surface temperature).

1 Introduction

Deflectograph accreditation trials are held annually by TRL on behalf of Highways England. The objective is to monitor the performance of all Deflectographs operating on the Highways England Strategic Road Network. By examining and monitoring the results from the machines operating on specified test sections, the performances of individual machines, and the whole UK fleet, are assessed.

The 2019 trial was held during the period 5th to 7th March 2019. The site used was the twin horizontal straights of the Horiba-MIRA proving ground which is further discussed in Section 2. This was the twenty-fourth year in which TRL have taken full responsibility for the planning and running of the trials and the seventh full trial at Horiba-MIRA. Ten machines attended the trial.

For convenience, throughout this report, the machines are referred to by their running numbers rather than by the owner. For ease of record keeping, running numbers are retained from year to year with any new machines being assigned new numbers. By agreement with Highways England, Appendix A lists the machines, owner and performance at the trial. This approach was also agreed with the ADEPT (formerly CSS) Deflectograph Operators Group before it disbanded.

2 Test site

2.1 Details of the test site

The twin horizontal straights area of the Horiba-MIRA Proving Ground comprises two lengths of straight and essentially level track just over 1.5km long joined by banked bends at either end. During October 2010 Highways England arranged for a length of the nearside lane on one of the straights to be reconstructed, in order to produce three sections of different constructions/strength levels. These three sections were designed specifically for use in the accreditation of Deflectographs and other pavement deflection measuring devices. These sections are referred to as HECP_01, HECP_02 and HECP_03 (Highways England Calibration Pavement) during this report. The sections are each 70m in length (however the beginning and end 5m are excluded in the analysis to help avoid alignment issues, resulting in 60m sections) and the layout and test route is shown in Figure B.1 in Appendix B. Nominal construction details of the test sections can be found in Appendix C.

In order to demonstrate the suitability of the sections constructed at Horiba-MIRA, a transitional trial was held on the 12th and 13th September 2011 (Brittain & Sanders, 2012). This trial compared a sub-set of the UK Deflectograph fleet, initially following the traditional approach using the historic test sections of the TRL track and then moving to follow the proposed new procedures and sections at Horiba-MIRA. The work demonstrated that the Horiba-MIRA site was suitable for the accreditation of Deflectograph machines. As well as the trial process, the accreditation criteria were reviewed following the 2011 transitional trial.

The trial process and the criteria used for the 2019 trial are discussed in Sections 3 and 4 of this report, respectively.

2.2 Variability of nearside (NS) deflections on HECP_02

During the transitional trial it was found that there was a localised high deflection area in the NS wheel path of section HECP_02. This high deflection area was traversed in some but not all runs and only affected the NS wheel path of section HECP_02. This is illustrated in Figure 2.1 which is a plot of some of the data collected at the transitional trial over the three test sections.

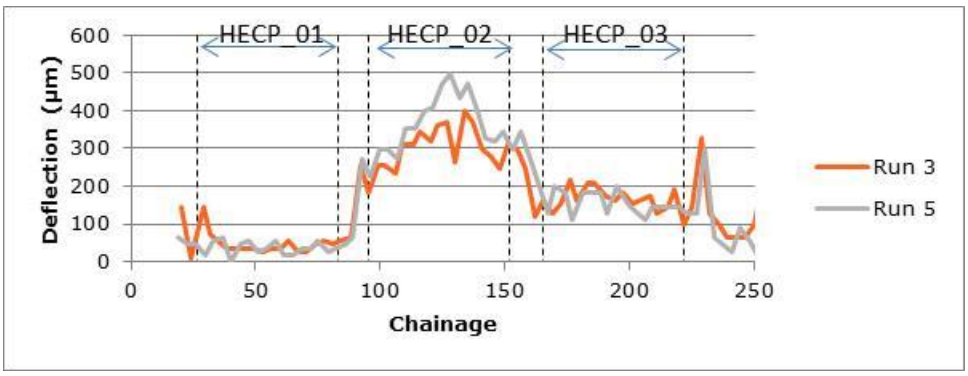

Figure 2.1: Example plot of nearside deflections for Horiba-MIRA test sections observed during the transitional trial

It was established that the high deflections occurred when the transverse location of the Deflectograph test line varied outside of the wheel path. In order to try and reduce this effect for the 2013 trial, small cones were placed on the test track to mark the survey test line for the whole test site. These cones were placed either side of the machine's test path (as shown in Figure 2.2), so that any deviation in the test line would cause a cone to be knocked over and thereby any deviation could be recorded.

Figure 2.2: Image illustrating cone positions during testing

During the analysis of the 2013 trial it was found that this approach reduced the variability of the deflections for the NS wheel path of HECP_02. It was therefore decided that these cones be placed along HECP_02 for all future trials in order to reduce this variability.

3 Trial format

The format of the 2019 trial was kept broadly the same as that of recent years, with two scheduled days of testing and one contingency day. The review of the accreditation trial procedure following the transitional trial recommended that checks on the distance calibrations of the machines should be included. This was incorporated into the 2012 trial and has been repeated in all subsequent trials.

Each crew carried out a machine inspection in advance of the trials and a certified checklist was submitted before the machine could be included in the running trials.

3.1 Day 1

The first day is dedicated to static inspections, distance calibrations and a warm-up lap to help identify any major issues.

On arrival, each machine is weighed to determine the loads applied by each wheel to the road surface. The wheel weight values are then used in the trial software to allow corrections for rear wheel weight to be applied to the deflection data.

The operators' thermometers are collected and are compared against each other in a stabilised environment.

The machines are then taken to the test track where the survey crew perform a distance calibration followed by a single lap of the test circuit to provide some preliminary data to try and identify any machines which may have any significant issues.

3.2 Day 2 and day 3

The second day is the main running trials. This includes repeat measurements of deflection, temperature and distance. If bad weather or other unforeseen circumstances arise then the contingency day (day 3) allows for additional time to conduct further tests.

On arrival at the test track the crews are asked to perform a static calibration before undertaking laps of the test sections.

Deflection measurements are made over the three test sections, and temperature measurements are collected by the survey crews using two pre-drilled holes (40mm depth) located before and after the deflection test sections. The distance check involves the crews surveying a length between two cones (separated by more than 400m) and comparing the distance measured to the reference measurement of the distance between the cones.

The machine running order is randomly determined before testing begins, with all machines running in convoy to cover all the sections in a single measurement run. Each machine is required to complete a minimum of five measurement runs. Data from the survey machines is handed in after each run and real-time data processing enables collated measurements to be available for review as the trials proceed.

In order to improve the alignment of data, at the start of each run crews are asked to stop their machines and align the deflection beam frame to the forward-most position of the test cycle with the truck wheels at a defined "beam down" point.

HD29/08 (Design Manual for Roads and Bridges, 2008) sets a maximum rate of temperature increase of 2.5˚C per hour at 40mm for deflection testing on the trunk road network. This requirement is intended to ensure that temperature corrections used to adjust deflections to a standard temperature of 20˚C stay within the validity of the equations.

Although temperature corrections are not carried out in analysing data from the accreditation trial, the temperature is monitored at the same location as the operator temperature measurements (i.e. before and after the deflection test sections) at 40 and 100mm depths to inform any conclusions drawn. Automatic data-loggers are used to provide a record every minute during deflection testing.

While the machines are running, TRL staff observed the dynamic operation of each machine, including a timed section in order to verify that operating speeds are acceptable.

4 Criteria for acceptability

The accreditation trial criteria are specified in "Accreditation and Quality Assurance of Deflectograph Survey Devices" (TRL, 2016). This document is a live document (i.e. is subject to change) and the most recent (July 2016) version of the document was used for the trial. The relevant section of the document is reproduced verbatim below in Section 4.1. Note in the text below, "Equipment" is a defined term and refers to the overall machine being assessed, incorporating the measuring systems and the survey vehicle. "System" refers to an individual measurement system installed on the Equipment e.g. the NS deflection measurement system, temperature measurement system etc. "Employer" refers to the organisation that commissions the Survey Contractor to complete a survey and will generally be the final user of the data provided. "Owner" refers to the organisation or individual to which the Equipment belongs and to whom Accreditation Certificates are awarded. Note that the copied text refers to other parts of the accreditation document which are not reproduced in this report.

4.1 Trial criteria from the Accreditation and QA document

E.3 Equipment inspection

E3.1 Contractors will be provided with an inspection check sheet to complete and provide to the Auditor in advance of the Trial. The Contractors will also be asked to supply evidence that the required Calibrations have been performed (see section C.4).

E3.2 Equipment will also be inspected at the trial to ensure that they are in a suitable condition to conduct the tests. This will include verifying that the Equipment appears to be in good general mechanical order.

E3.3 Equipment will be weighed so that Load normalisation of the survey data can be carried out. The Equipment should be within the limits given in Table 1.

Table 1 – Criteria for wheel weights

Parameter	Acceptability Limit
Front Axle[1]	4500 kg ±5%
Twin rear wheel	3175 kg ±10%

E3.4 A simple of assessment of the temperature measurement System should be carried out to make sure that it is producing consistent results.

[1] It has been the experience in the Accreditation Trials that Equipment falling within approximately 10% of target limit for the front axle has performed acceptably with regards to deflection measurements. This matter has been investigated by TRL and Highways England. It has been concluded that, while consideration may be given to revising the specification limits at an appropriate point in the future, for the time being Equipment falling within this approximate front axle range would continue to be regarded as acceptable provided that they performed satisfactorily in the dynamic tests.

E.4 Running Trials

E4.1 Overview

E4.1.1 As detailed in in Appendix B, trials will be carried out on a test site separated into test stations, and laid out such that "laps" of the set of test sections can be undertaken by the Fleet for the purposes of repeating the measurements.

E4.2 Deflection testing – Mandatory Requirement

E4.2.1 The assessment for Deflection measurements is described below, and a worked example is provided in Appendix C

E4.2.2 The Equipment will undertake laps so that the following criteria are met:

- At least 5 laps are undertaken that comply with the requirements for Reference Data (see Appendix B, App B.3)
- Survey data will be collected at a target test speed of 2.4 km/h. Equipment will be checked by measuring the time taken to travel a known length. If the Equipment is found to be surveying more than 0.1km/h from this target, the survey operator will be asked to adjust their speed accordingly.
- The pavement temperature measured at a depth of 40mm must not change by more than ±2.5°C during the test lap.

E4.2.3 The Contractor will supply the deflection measurements for their Equipment from each test lap in the file formats specified by the Auditor.

E4.2.4 The Auditor will calculate:

- The load corrected mean for the Equipment for each wheel path and test section.
- The standard deviation of these mean values for the Fleet and for all of the Equipment at the trial, referred to as the Fleet between-Equipment standard deviation (BESD) and the Trial BESD. These values will be used to assess the consistency of the Equipment at the Trial.
- The standard deviation of the deflection values between laps for the Equipment for each wheel path and test section. This data is referred to as the between-run standard deviation (BRSD). These values will be used to assess the repeatability of each individual Equipment.

E4.2.5 The BRSD will be used in the initial assessment of each Equipment. During the Tests, the BRSD values will be affected by the variability of pavement temperatures during the course of the testing. Therefore the performance will be assessed by comparison against the performance of the other Equipment undertaking the Re-accreditation/Accreditation Tests.

E4.2.6 Where the BRSD values of the Equipment are significantly higher than the BRSD values of other individual Fleet Equipment, the data from the Equipment will undergo further investigation by the Auditor to determine if the Equipment is suitable for Accreditation.

E4.2.7 The Trial BESD is acceptable if it is below the criterion given in Table 2. If the trial BESD exceeds this criterion then the data will be further examined to identify outlying Equipment. This will include examining the Fleet BESD and data from individual Equipment. Outlying Equipment will be rejected and the data reassessed until the performance is acceptable.

E4.2.8 In addition, any Equipment that deviates by more than 3 times the BESD criterion from the Fleet Mean will fail Accreditation. Any Equipment that is between two and three times the BESD criterion from the Fleet mean will undergo further investigation by the Auditor to determine if the Equipment is suitable for Accreditation.

E4.2.9 The data from any Equipment rejected due to BRSD, BESD or otherwise identified as an outlier will not be used in the calculation of the Reference Data (App B.3.1).

Table 2 – Criterion for Deflection measurements

Parameter	Acceptability Limit
Between Equipment standard deviation (BESD)	≤0.0257 * Reference Data+9.88 (µm)

E4.2.10 The performance will be assessed for both wheel paths separately. To achieve Accreditation the Equipment must meet the requirements for both the NS wheel path and the OS wheel path.

E4.3 Location Referencing (Distance) – Mandatory Requirement

E4.3.1 Accreditation of an Equipment's ability to measure distance is carried out by comparing its measurements of a test length with the Reference Data (App B.3.2), repeated at least five times. The criteria applied to the test measurements are given in Table 3. Note: the tolerance allows for the basic method by which events are recorded in Deflectograph Survey Data.

Table 3 – Criteria for Measurement of Distance travelled

Parameter	Acceptability Limit
Distance measured	80% within 5m

E.5 Additional Tests

E5.1 Overview

E5.1.1 The criteria in this sub-section are specified as High, Medium and Low levels of performance. This reflects the lower level of maturity of this test. In future revisions to this document these may become mandatory criteria.

E5.1.2 Some Employers may require a specific level of performance in some or all of these additional tests to carry out Accredited Surveys on their Network.

E5.2 Temperature measurement – temperature sensor for measurement at depth

E5.2.1 If undertaking this test, the Contractor will be required to make measurements from holes supplied by the Auditor (40mm depth) so that at least eight measurements are taken during the course of the test laps. The criteria for the assessment of temperature measurement at depth are given in Table 4.

Table 4– Criteria for temperature measurement at depth

Performance level	Measurement of temperature
High	80% of the measurements are within 1˚C of the reference
Medium	50% of the measurements are within 1˚C of the reference
Low	15% of the measurements are within 1˚C of the reference
Not Suitable	Otherwise

E5.3 Temperature measurement – temperature sensor for surface measurement

E5.3.1 If undertaking this test, the Contractor will be required to make measurements of the surface temperature so that at least eight measurements are taken during the course of the test laps. The criteria for the assessment of surface temperature measurement are given in Table 4.

Table 5– Criteria for surface temperature measurement

Performance level	Measurement of temperature
High	80% of the measurements are within 1˚C of the reference
Medium	50% of the measurements are within 1˚C of the reference
Low	15% of the measurements are within 1˚C of the reference
Not Suitable	Otherwise

5 Results – Inspection day (5th March 2019)

5.1 Inspections

All ten machines arrived with completed inspection checklists and in acceptable condition.

5.2 Wheel weights

The weights recorded for each machine are given in Table 5.1.

Table 5.1: Deflectograph weight distributions from 5 March 2019

Machine	Weight distribution including crew (kg)						
	Front NS	Front OS	Total Front	Rear NS	Rear OS	Total rear	Total Machine
2	2440	2610	**5050***	3320	3315	6635	11685
3	2335	2410	**4745***	3470	3445	6915	11660
5	2380	2340	4720	3340	3395	6735	11455
8	2235	2425	4660	3250	3265	6515	11175
9	2395	2380	**4775***	3275	3215	6490	11265
10	2355	2365	4720	3485	3225	6710	11430
12	2215	2340	4555	3410	3355	6765	11320
14	2390	2405	**4795***	3215	3425	6640	11435
15	2410	2555	**4965***	3415	3375	6790	11755
16	2245	2390	4635	3275	3265	6540	11175

* Exceeds tolerance defined in HD29 (see comment in Section 5.2)

Machines 2, 3, 9, 14 and 15 exceeded the published front axle limits. Machines 2 and 15 have exceeded the published limit since their introduction into the fleet. However, ever since Machine 2 (and, subsequently Machine 15) was introduced, there has been no measurable effect from the heavier front axle weight. This matter was reviewed by TRL and Highways England following the 2004 trials. It was concluded that, while consideration may be given to revising the specification limits at an appropriate point in the future, for the time being the differences will be noted but the affected machines would continue to be regarded as acceptable provided that they performed satisfactorily in the dynamic tests.

In the latest version of the accreditation and QA specification (see section 4.1) it notes that in the past devices falling within approximately 10% of the target limit for the front axle have been seen to perform acceptably with regards to deflection measurements. It is noted that two machines (Machine 2 and Machine 15) exceed the target by more than 10% (12.2% and 10.3% respectively). However, it was decided that the same approach (noting the difference and regarding them as acceptable provided that they perform satisfactorily in the dynamic tests).

5.3 Warm-up lap

Following the processing of data from the warm-up lap it was found that the spread of machine results was within the criteria for the average of the site (but not for HECP_02 and HECP_03 on the near side wheel path). No machines were identified as requiring further investigation at this stage.

5.4 Temperature probes

The operators' thermometers were collected up and the probes allowed to stabilise to the same temperature (in a water container). No significant issues were identified from this check.

6 Results – Main trial day (6th March 2019)

6.1 Beam calibration check

Prior to the main running trials each crew carried out a static beam calibration check on their machine. No machines were identified to TRL as not meeting the limits specified in HD29/08.

6.2 Distance measurement

A distance check length was set up on the track to assess the distance measurement systems on the machines. The reference length used was 409.617m. During the trial, the survey crews were asked to test the reference length and note down on the run log sheets the distance measured. This involves opening up the survey file and identifying the length between the two marker points. The crews were also asked to provide these survey files.

After the trial the operator-reported lengths were compared with the lengths in the survey files and it was noted that many of the operators did not perform the calculation correctly. During normal use of the survey vehicles this calculation is not required, therefore it is not an issue for their ongoing use. For the assessment of the survey vehicles' performance, the distances recorded in the survey files were used.

The difference between the measured length from each machine and the reference length, along with the overall performance, are given in Table 6.1. The differences between the machine and the reference are highlighted in red bold text where it exceeds the threshold for the criteria as set out in Section 4.1.

Table 6.1: Distance measurement results

Machine	Difference between measured length and the reference (m)						% within criteria	Performance
	1	2	3	4	5	6		
2	0.4	-0.6	-1.6	1.4	0.4	0.4	100	Pass
3	-3.6	-3.6	-3.6	-3.6	-3.6	-1.6	100	Pass
5	-3.6	-0.6	-2.6	0.4	-1.6	-3.6	100	Pass
8	1.4	-1.6	0.4	-0.6	-0.6	-1.6	100	Pass
9	-2.6	-3.6	-2.6	.	.	.	100	Only 3 tests
10	0.4	-1.6	0.4	-1.6	-0.6	1.4	100	Pass
12	3.4	-3.6	**-5.6**	-1.6	0.4	0.4	83	Pass
14	0.4	0.4	1.4	-1.6	**-5.6**	.	80	Pass
15	-0.6	-1.6	1.4	-0.6	0.4	-1.6	100	Pass
16	1.4	0.4	0.4	-0.6	1.4	-0.6	100	Pass

From Table 6.1 it can be seen that nine machines passed the distance measurement criteria on the main trial day. One machine (Machine 9) only carried out 3 tests on the main trial day and was further assessed on the contingency day. This testing is further discussed in Section 7.

6.3 Temperatures

6.3.1 Temperature pattern shown by the data loggers

Data loggers were connected to thermocouples in order to record the 40mm and 100mm depth temperatures along with the air and pavement surface temperatures. The loggers were set-up to record the measurements every minute. This data was then smoothed by taking a 9 point moving average (4 points before the time, the time and 4 points after). This smoothed data is shown in Figure 6.1 and Figure 6.2.

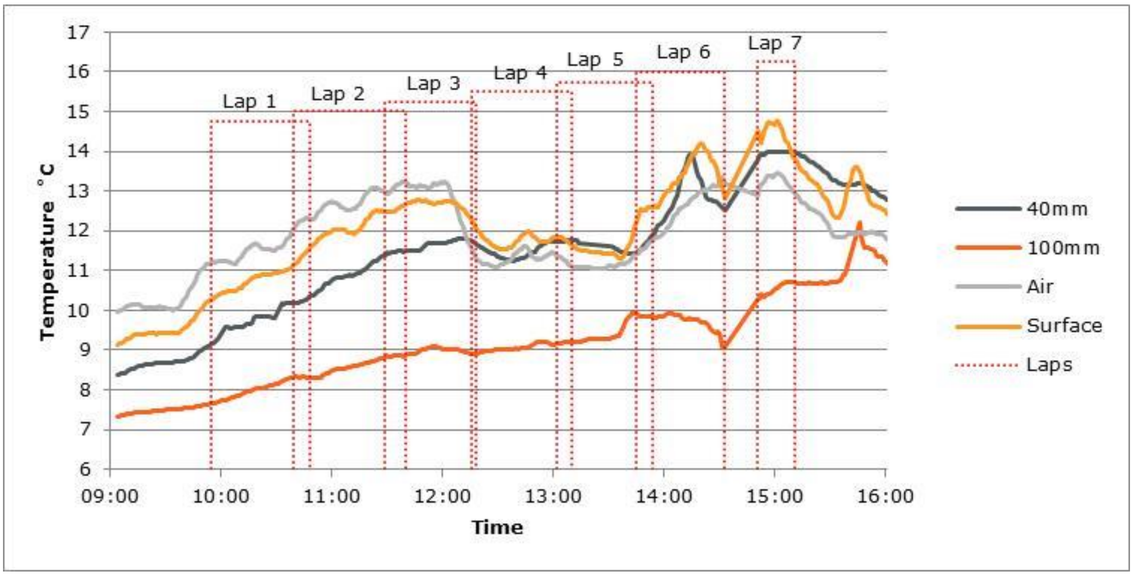

Figure 6.1: Temperature measurements from temperature station 1 (before test sections)

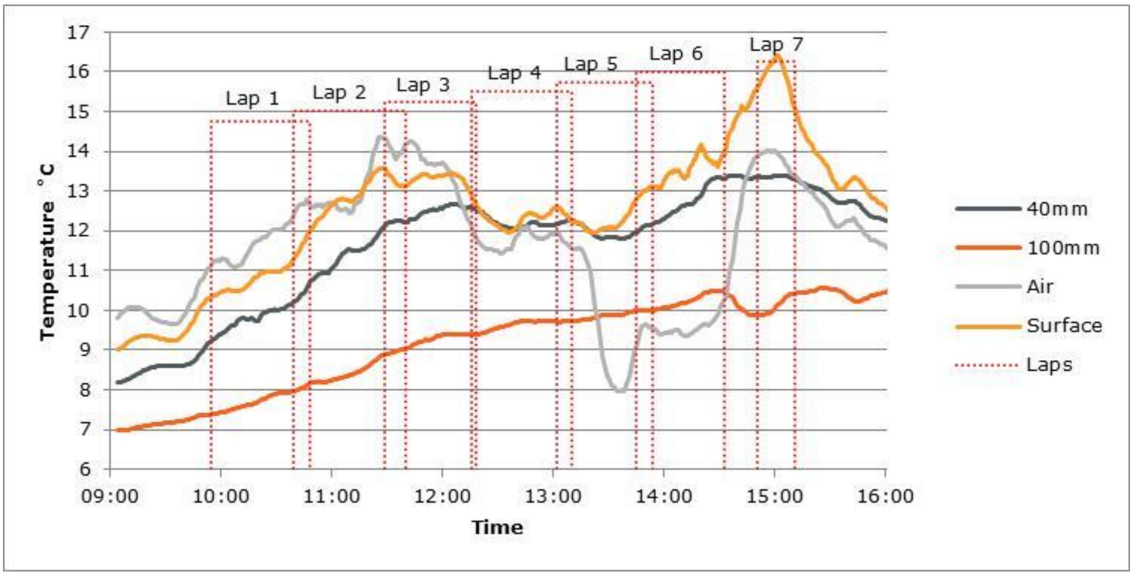

Figure 6.2: Temperature measurements from temperature station 2 (after test sections)

With the exception of the air temperature at station 2, the graphs show a general steady increase in the temperatures over the course of the day. The anomaly with the recorded air temperature at station 2 should be treated as suspect, as the change is not seen in any of the other measurements (including the air temperature at station 1).

As discussed in Section 3.2, HD29/08 sets a maximum rate of temperature change of 2.5˚C per hour at 40mm for deflection testing. The temperature change per hour (calculated for each 15 minute interval) is shown in Figure 6.3.

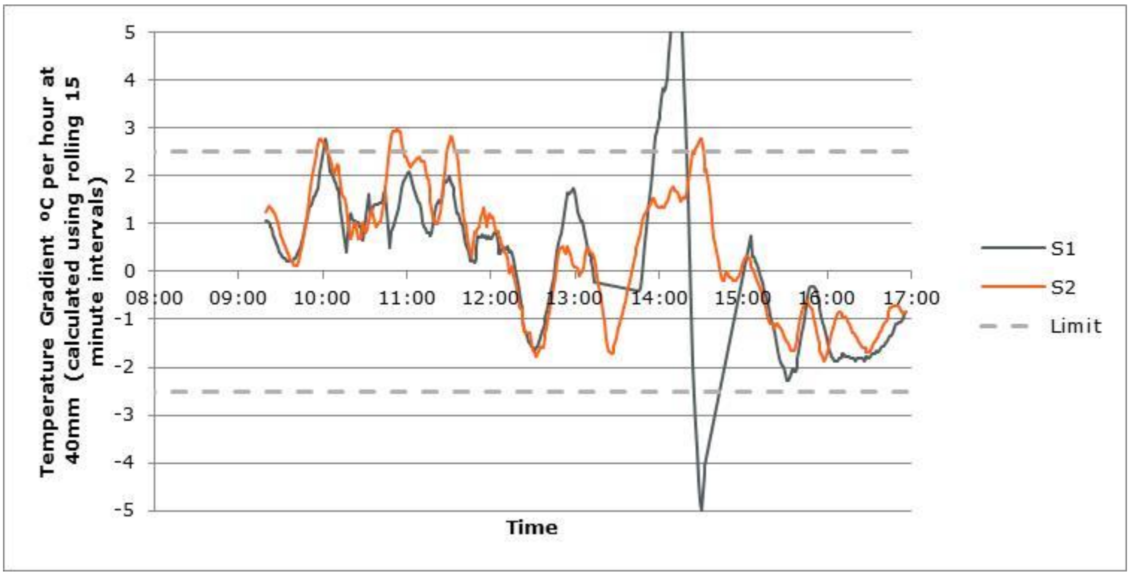

Figure 6.3: 40mm depth temperature changes (rolling 15 minute intervals), main trial day

From Figure 6.3 it can be seen that the 2.5˚C per hour criteria is exceeded at several points between 09:50 and 11:30, and then again between 14:00 and 14:30. Therefore if additional variation is seen in the survey data in laps covering these periods (laps 1/2 and Lap 6) then they may be disregarded and additional laps carried out.

6.3.2 Temperatures at depth, recorded by operators

The Deflectograph crews made measurements of temperature from the two temperature test stations at a 40mm depth. This data is shown in Figure 6.4 and Figure 6.5.

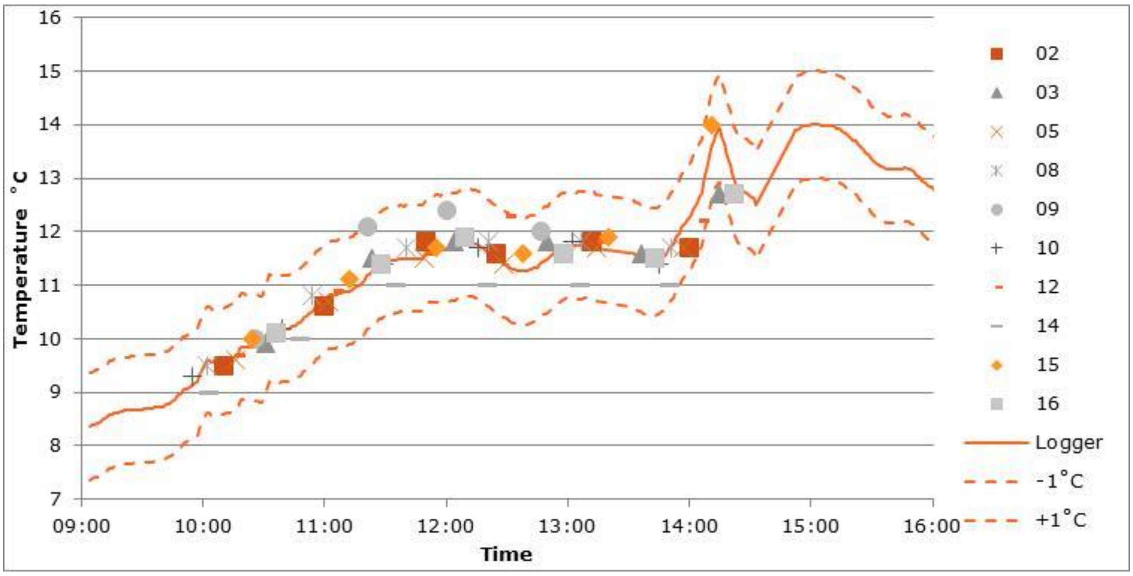

Figure 6.4: Comparison of operators' measurements against reference – Temperature test station 1, main trial day

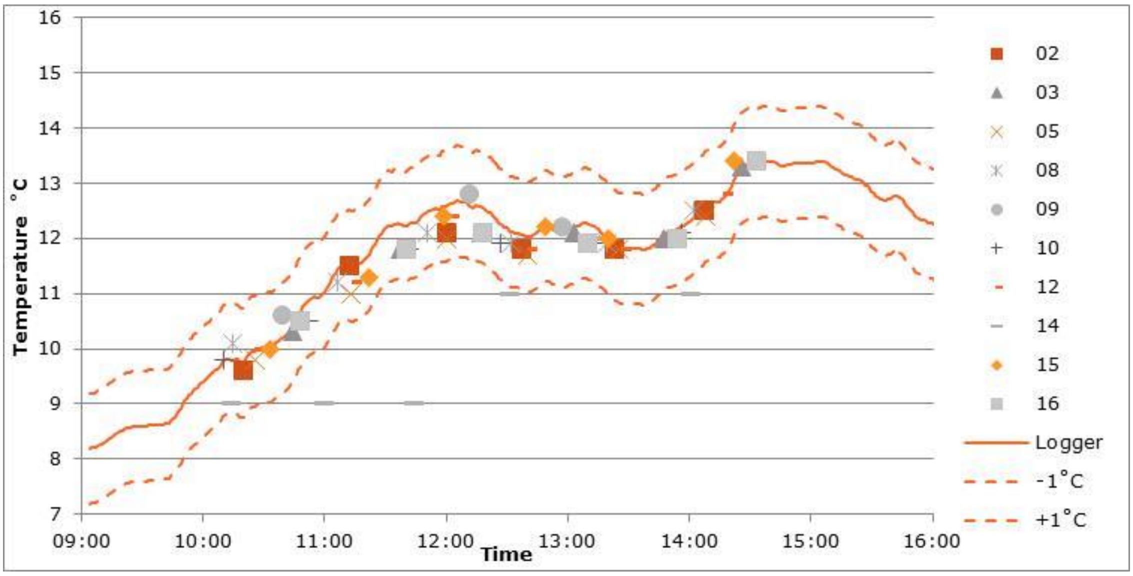

Figure 6.5: Comparison of operators' measurements against reference – Temperature test station 2, main trial day

The difference between the operators' measured values and the reference and the awarded performance are shown in Table 6.2. If the recorded value is more than 1˚C away from the reference then it is highlighted in bold red text.

Table 6.2: Difference between operators 40mm measured values and the reference

Machine	Difference between measured temperature and reference (˚C)												% within criteria	Performance band
	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6			
	1	2	1	2	1	2	1	2	1	2	1	2		
2	-0.1	-0.1	-0.2	0.0	0.2	-0.5	0.1	-0.3	0.0	-0.1	-0.6	0.0	100	High
3	.	-0.1	0.3	-0.5	0.1	-0.5	0.3	-0.1	0.1	0.0	**1.2**	0.0	90.9	High
5	-0.1	-0.2	-0.1	-0.5	0.0	-0.6	0.0	-0.3	0.0	0.0	.	-0.2	100	High
8	-0.1	0.3	0.3	-0.2	0.2	-0.4	0.2	-0.2	0.1	-0.1	.	0.1	100	High
9	*0.2*	*0.4*	*0.9*	*.*	*0.7*	*0.2*	*0.6*	*0.1*	*.*	*.*	*.*	*.*	*100*	*Only 7 tests*
10	0.2	0.0	0.0	-0.4	0.0	-0.5	0.0	-0.4	0.1	-0.3	-0.4	-0.1	100	High
12	0.0	0.0	0.1	-0.3	0.0	-0.2	0.9	-0.2	.	0.0	.	0.1	100	High
14	-0.6	-0.8	-0.3	**-2.0**	-0.5	**-3.3**	-0.6	**-1.2**	-0.7	-0.1	.	**-1.3**	63.6	Medium
15	0.2	0.0	0.2	-0.4	0.0	-0.2	0.3	0.0	.	0.0	.	0.4	100	High
16	-0.1	-0.2	0.0	-0.4	0.1	-0.4	-0.1	-0.4	0.1	-0.2	0.8	0.1	100	High

Eight machines achieved a high performance and one machine (Machine 14) achieved a medium performance. One further machine (Machine 9) only carried out 7 tests on the main trial day and was further assessed on the contingency day. This testing is discussed in Section 7.

6.3.3 Air and Surface temperatures, recorded by operators

Methodologies for estimating pavement temperature from measurements of air and surface temperatures have been developed for use with deflection surveys. The replacement to HD29, CS 229 (due to be published in 2020) will permit survey contractors to use air and surface temperature measurements to estimate 40mm pavement temperatures. Anticipating this change, the Accreditation and QA specification (TRL, 2016) was amended to include criteria for the assessment of pavement surface temperatures measured using an infrared temperature probe mounted on the Deflectograph. Assessment criteria for air measurements using a thermometer device mounted on the Deflectograph will be included in a future version of the document.

To help develop the assessment method and test the criteria, survey contractors were asked to supply air and surface measurements (if they had the equipment fitted) from the test laps on the main trial day. This data would be used to provide an assessment of the surface temperature measurement accuracy and provide a general picture of the performance of the air temperature measurements. In both cases the data will be used to help develop the methodology for assessing the performance of the devices.

At the trial, air and surface temperature data was supplied from four machines. Data was collected from the same two locations as the 40mm temperature holes (before and after the test sections). The surface temperatures from the logger and the data supplied from the operators is shown in Figure 6.6 and Figure 6.7.

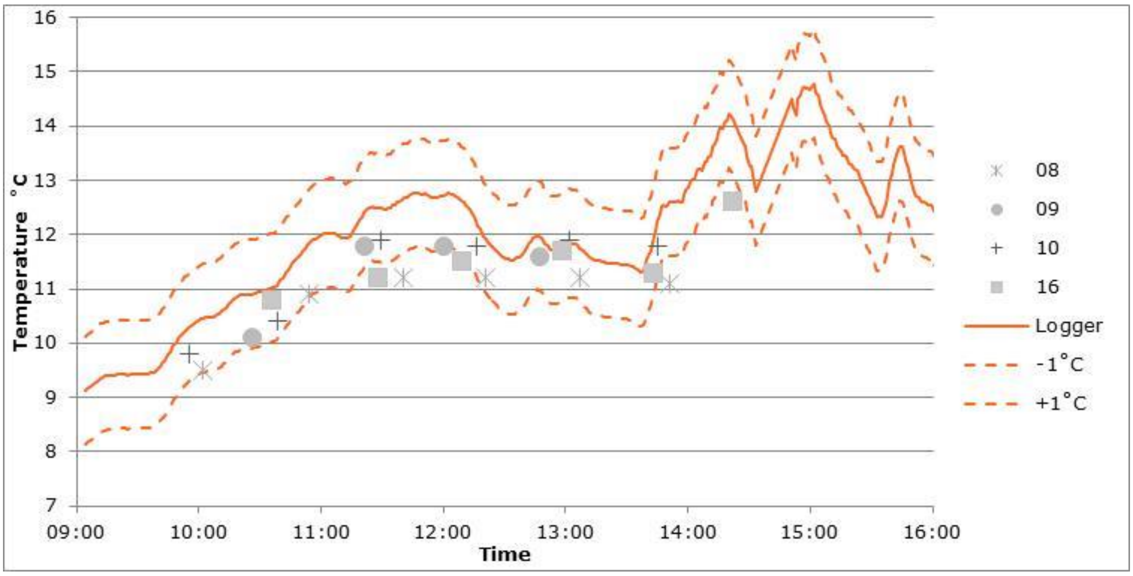

Figure 6.6: Surface temperatures – Temperature test station 1, main trial day

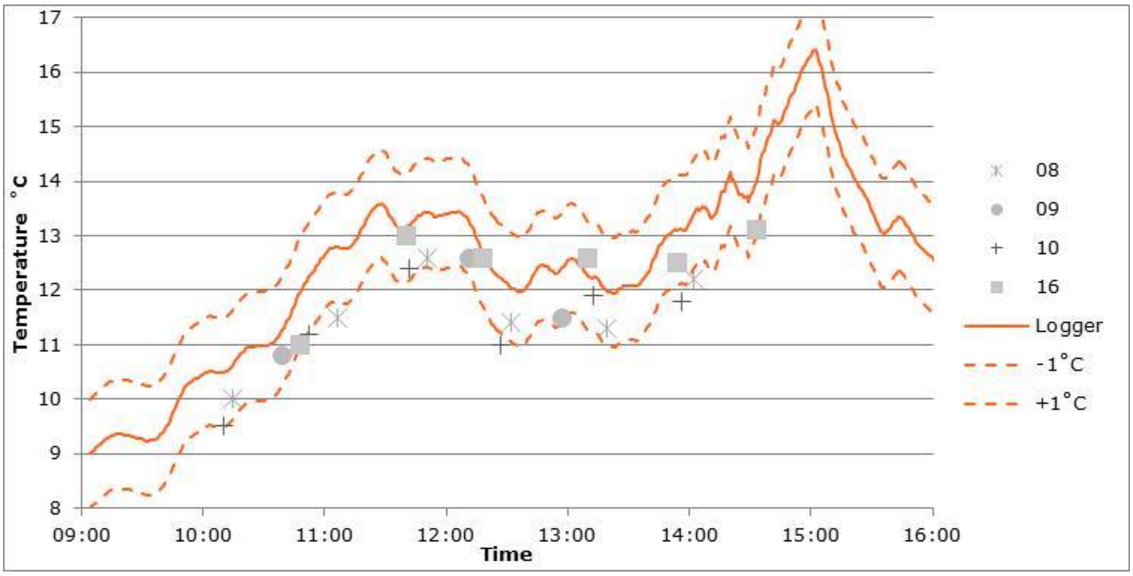

Figure 6.7: Surface temperatures – Temperature test station 2, main trial day

The difference between the surface temperatures recorded by the Deflectographs and the reference are shown in Table 6.3 along with the awarded performance.

Table 6.3: Difference between operators surface temperature values and the reference

Machine	Difference between measured temperature and reference (˚C)												% within criteria	Performance band
	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6			
	1	2	1	2	1	2	1	2	1	2	1	2		
8	-1.0	-0.7	-0.9	**-1.3**	**-1.5**	-0.8	-0.7	-0.7	-0.6	-0.7	**-1.5**	**-1.2**	66.6	Medium
9	-0.8	-0.5	-0.6	.	-0.9	-0.7	-0.4	-0.9	.	.	.	.	*100*	*Only 7 tests*
10	-0.5	-1.0	-0.7	**-1.0**	-0.6	-0.8	-0.4	**-1.2**	0.1	-0.3	-0.4	-1.3	75	Medium
16	-0.2	-1.0	**-1.3**	-0.1	**-1.1**	-0.1	-0.1	0.4	-0.6	-0.6	**-1.5**	-0.9	75	Medium

Three machines achieved a medium performance. One machine (Machine 9) only carried out 7 tests on the main trial day and was further assessed on the contingency day. This testing is further discussed in Section 7.

The air temperatures from the logger and the data supplied from the operators is shown in Figure 6.8 and Figure 6.9.

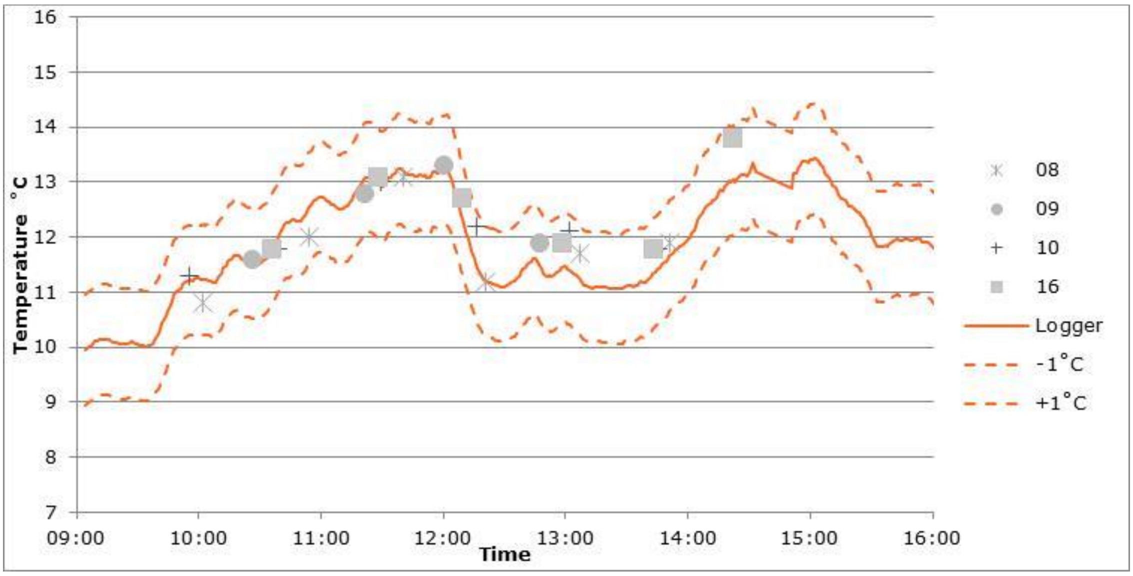

Figure 6.8: Air temperatures – Temperature test station 1, main trial day

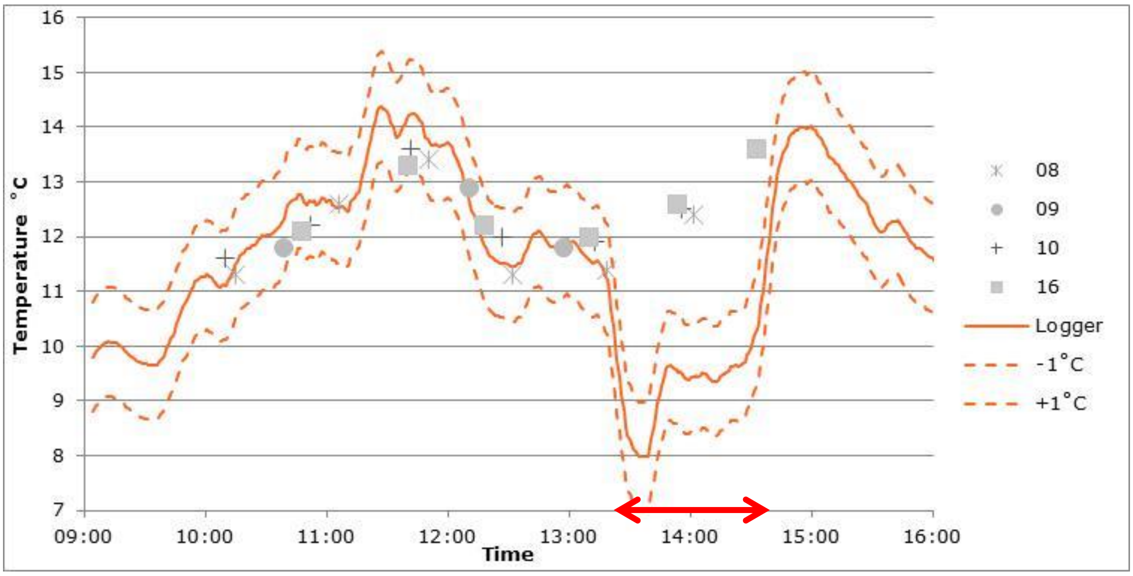

Figure 6.9: Air temperatures – Temperature test station 2, main trial day

Examination of Figure 6.8 and Figure 6.9 shows that the spread of data is reasonably consistent with a requirement to be within 1°C of the reference. In section 6.3.1 it was noted that the air temperatures recorded for section 2 between approximately 13:30 and 15:00 were unusual (highlighted with a red arrow). As such this timeframe may need to be investigated further or excluded from the analysis. The difference between the air temperatures recorded by the Deflectographs and the reference are shown in Table 6.4 along with the performance if they are assessed against the same criteria for the surface temperatures.

Table 6.4: Difference between operators air temperature values and the reference

Machine	Difference between measured temperature and reference (˚C)												% within criteria	Performance band
	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6			
	1	2	1	2	1	2	1	2	1	2	1	2		
8	-0.4	-0.2	-0.5	0.1	-0.1	-0.3	0.0	-0.1	0.5	0.2	0.2	**3.0**	91.6	High
9	*0.1*	*-0.5*	*-0.3*	*.*	*0.1*	*0.3*	*0.4*	*-0.1*	*.*	*.*	*.*	*.*	*100*	*Only 7 tests*
10	0.1	0.5	-0.2	-0.5	0.1	-0.6	0.7	0.5	0.7	0.4	0.4	**3.0**	91.6	High
16	0.0	-0.6	0.1	-0.9	0.3	0.3	0.5	0.4	0.5	**3.1**	0.8	**3.3**	83.3	High

Three machines achieved a high performance (as such the data from station 2 between 13:30 and 15:00 was not investigated). One machine (Machine 9) only carried out 7 tests on the main trial day and was further assessed on the contingency day. This testing is further discussed in section 7.

6.4 Deflection readings – Main trial day

Due to technical issues with some of the machines it was decided that the first lap would be disregarded and an additional lap (lap 6) would be undertaken. In other words, the machines would be assessed using laps 2 to 6.

During the early laps it was identified that Machine 9 was recording deflections significantly lower than the rest of the fleet. This machine was removed from the testing for investigation, and took part in occasional testing during the rest of the day. The data from this machine is excluded from the tables below and the performance of this device is further discussed in Section 6.5.

6.4.1 Between run standard deviation for deflection values

No criteria are set relating to the between run standard deviation of each machine. It is, however, useful to consider this aspect when investigating anomalies in the behaviour of machines in case an individual machine's mean result has been unduly influenced by variations between runs, perhaps as a result of a significant variation from the expected test line. The variation between runs is indicated by the between-run standard deviation for each machine, as shown in Table 6.5.

Table 6.5: Between run standard deviation for main running day (day 2)

Machine number	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
2	3.7	3.9	10.4	5.9	7.1	6.7
3	5.1	7.6	8.1	11.1	10.4	4.8
5	3.9	5.3	10.2	9.7	9.3	6.5
8	7.0	2.8	8.8	7.0	12.4	5.7
10	3.9	4.1	7.5	4.4	7.4	9.7
12	2.9	1.8	11.9	7.0	6.4	5.6
14	3.1	2.1	7.9	4.1	6.4	4.1
15	5.1	4.3	17.2	8.9	7.8	5.5
16	3.8	2.4	2.9	5.3	9.3	11.2

It can be seen from Table 6.5 that despite some variation in the values, no machine was obviously more variable on average than the others.

6.4.2 Mean deflection values

Table 6.6 shows the mean deflections recorded on each section, together with summary statistics. Instances where the between equipment standard deviation (BESD) is within the criterion are highlighted in green and instances where the criterion is not met are in red. Table 6.7 shows the deviations from the overall mean and these are highlighted if they are more than 2 or 3 times the BESD criteria (orange and red respectively).

Table 6.6: Mean deflection (µm) by section: Main running day

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	57	58	261	235	161	164	160	152
3	30	41	239	212	125	128	131	127
5	54	44	258	204	163	145	158	131
8	61	54	263	229	161	162	162	148
10	55	51	257	223	153	159	155	144
12	51	46	261	199	149	139	154	128
14	68	57	283	218	181	158	177	144
15	56	54	257	203	156	143	156	133
16	60	58	268	222	161	151	163	144
Mean	55	51	261	216	157	150	157	139
BESD	10.3	6.3	11.6	12.5	14.8	12.1	11.9	9.4
BESD criterion	11.3	11.2	16.6	15.4	13.9	13.7	13.9	13.5
CoV	18.9%	12.2%	4.4%	5.8%	9.5%	8.1%	7.6%	6.8%

Table 6.7: Deviation (µm) from overall mean deflection by section: Main running day

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	2.6	6.2	0.3	19.2	4.8	13.9	2.6	13.1
3	-24.3	-9.9	-21.8	-4.2	-31.6	-22.2	-25.9	-12.1
5	-0.6	-7.7	-3.2	-11.9	6.3	-4.9	0.8	-8.1
8	6.1	2.9	2.2	12.9	4.3	12.1	4.2	9.3
10	0.6	-0.2	-3.5	6.5	-3.4	8.8	-2.1	5.0
12	-3.5	-5.8	-0.1	-17.3	-8.0	-10.9	-3.9	-11.3
14	13.1	5.3	22.3	1.9	24.1	8.7	19.8	5.3
15	1.2	2.5	-3.8	-13.1	-0.5	-6.9	-1.0	-5.8
16	5.0	6.7	7.5	6.1	4.1	1.3	5.5	4.7
2x BESD criterion	22.6	22.4	33.2	30.9	27.8	27.5	27.8	26.9
3x BESD criterion	33.8	33.6	49.8	46.3	41.7	41.2	41.8	40.4

From Table 6.6 it can be seen that the BESD criteria is met for the average of the site, and all but one wheel path on one test section. In addition from Table 6.7 it can be seen that all machines are within 3 times the BESD criterion of the fleet mean. One machine (Machine 3) is between 2 and 3 times the BESD criterion on two of the test sections (HECP_01 and HECP_03) for the NS measurements. This machine is only just above the 2 times BESD criterion on these sections and therefore is deemed to be suitable. Therefore these nine machines are considered as meeting the trial criteria for deflection measurement.

6.5 Decision on use of the contingency day

The original plan for the trial was to use the contingency day only where it was not possible to conduct all of the testing on the main trial day due to bad weather or other unforeseen circumstances (e.g. a "stop testing" call from track control due to an emergency). However if there is sufficient reason to believe that a machine can be investigated and fixed between the end of the main trial day and before the contingency day, then additional testing may be conducted.

In this case, a lap conducted by Machine 9 towards the end of the main trial day appeared to provide deflection measurements that were consistent with the fleet. A number of changes were required to the equipment installed on machine 9 before the deflection results were deemed suitable. This included changing the winch on the vehicle (a number of times) along with the actual measurement recording boxes. This trial and error process highlights both a sensitivity of the measurement devices to the installation of exactly the right components and perhaps the limitations of this aging technology. As Machine 9 achieved this state towards the end of the main trial day it was not possible to get a full set of five laps with this machine on the main trial day. It was therefore decided that the contingency day be used to complete the testing for this machine. The results from this are discussed in Section 7.

7 Results – Contingency day (7th March 2019)

Additional testing was carried out on the contingency to carry out the assessment for Machine 9. For this testing Machines 8, 10 and 14 also took part to provide reference data for the deflection measurements.

7.1 Distance measurement

On the contingency day Machine 9 undertook two distance measurements. This data, along with the three measurements taken on the main trial day, are shown in Table 7.1

Table 7.1: Distance measurement

Machine	Difference between measured length and the reference (m)					% within criteria	Performance
	1	2	3	4	5		
9	-2.6	-3.6	-2.6	-1.6	-3.6	100	Pass

7.2 Temperatures

The crew for Machine 9 collected temperature at depth and air and surface temperatures on the contingency day to complete the temperature assessments. They collected data on two laps, so that four sets of temperature measurements (two at station 1 and two at station 1) were collected.

7.2.1 Temperatures at depth

The temperature at depth data from Machine 9 on the contingency day are shown in Figure 7.1 and Figure 7.2.

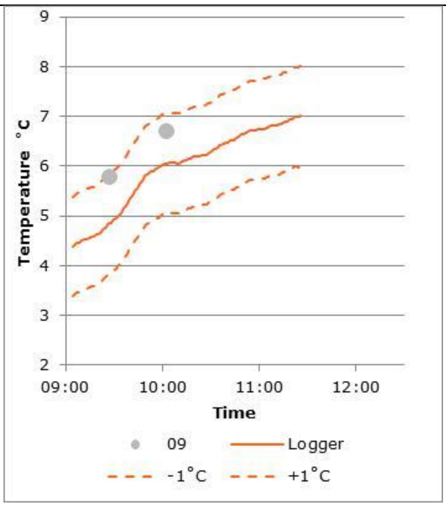

Figure 7.1: 40mm depth temperatures – Temperature test station 1, contingency day

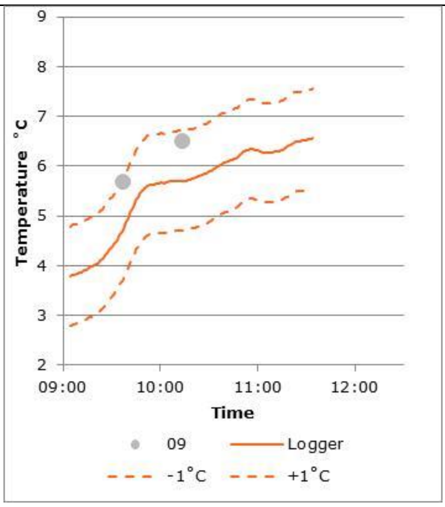

Figure 7.2: 40mm depth temperatures– Temperature test station 2, contingency day

The difference between the temperature at depth measurements for Machine 9 on the main trial day and the contingency day, and the awarded performance are shown in Table 7.2.

Table 7.2: Difference between 40mm measured values for Machine 9 and the reference

Machine	Difference between measured temperature and reference (˚C)												% within criteria	Performance band
	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6			
	1	2	1	2	1	2	1	2	1	2	1	2		
9	0.2	0.4	0.9	.	0.7	0.2	0.6	0.1	1.0	1.0	0.6	0.8	100	High

Using the combined dataset, Machine 9 achieves a high performance rating for the measurement of 40mm temperature.

7.2.2 Surface Temperature

The surface temperature data from Machine 9 on the contingency day is shown below in Figure 7.3 and Figure 7.4.

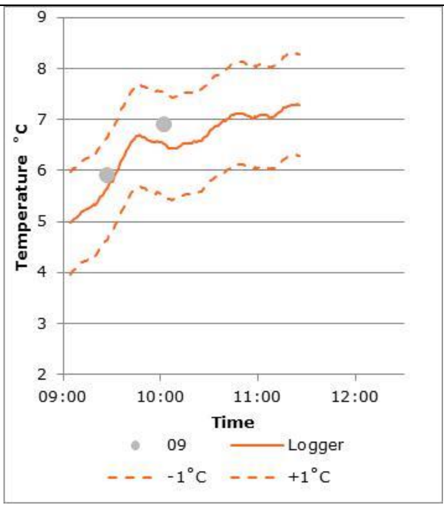

Figure 7.3: Surface temperatures – Temperature test station 1, contingency day

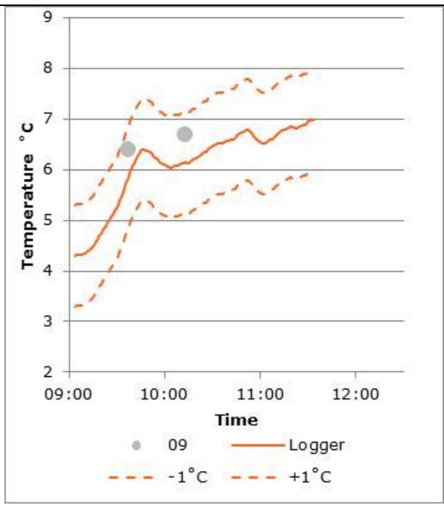

Figure 7.4: Surface temperatures – Temperature test station 2, contingency day

The difference between the surface temperatures measurements for Machine 9 on the main trial day and the contingency day, and the awarded performance are shown in Table 7.3. Where a recorded value is more than 1˚C away from the reference, it is highlighted in bold red text.

Table 7.3: Difference between surface temperature measured by Machine 9 and the reference

Machine	Difference between measured temperature and reference (˚C)												% within criteria	Performance band
	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6			
	1	2	1	2	1	2	1	2	1	2	1	2		
9	-0.8	-0.5	-0.6	.	-0.9	-0.7	-0.4	-0.9	0.3	**1.7**	0.4	1.0	90.9	High

Therefore for the combined dataset Machine 9 achieves a high performance rating for the measurement of surface temperature.

7.2.3 Air Temperature

The air temperature data from Machine 9 on the contingency day is shown below in Figure 7.5 and Figure 7.6.

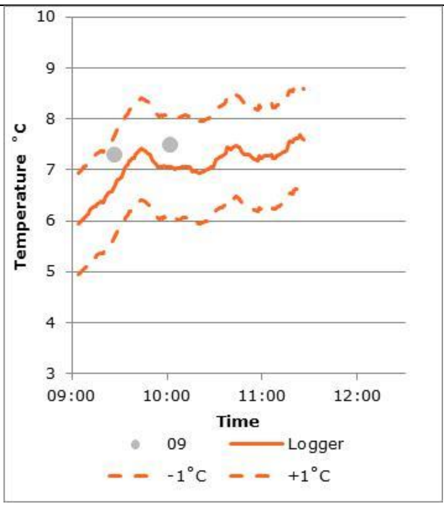

Figure 7.5: Air temperatures – Temperature test station 1, contingency day

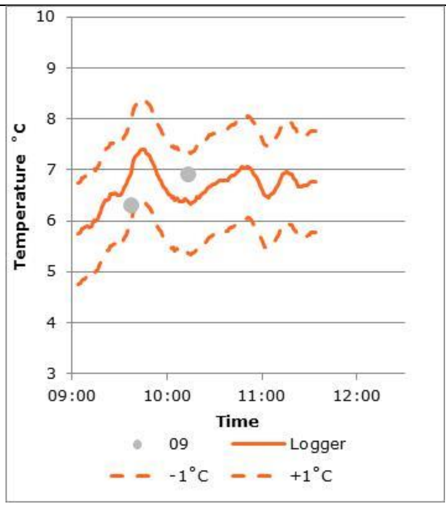

Figure 7.6: Air temperatures – Temperature test station 2, contingency day

The difference between the air temperature measurements for Machine 9 on the main trial day and the contingency day, and the awarded performance are shown in Table 7.4. Where the recorded value is more than 1˚C away from the reference, it is highlighted in bold red text.

Table 7.4: Difference between air temperatures measured by Machine 9 and the reference

Machine	Difference between measured temperature and reference (˚C)												% within criteria	Performance band
	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6			
	1	2	1	2	1	2	1	2	1	2	1	2		
9	0.1	-0.5	-1.0	.	0.1	0.3	0.4	-0.1	0.6	**1.6**	0.5	**1.2**	81.8	High

Therefore, for the combined dataset Machine 9 achieves a high performance rating for the measurement of air temperature.

7.3 Deflection measurement

For this testing Machines 8, 10 and 14 were used to provide reference data.

7.3.1 Between run standard deviation for deflection values

As noted in Section 6.4.1 although there are no criteria set relating to the between run standard deviation, it is useful to consider this aspect when investigating the behaviour of machines in case an individual machine's mean result has been unduly influenced by variations between runs. The variation between runs is indicated by the between-run standard deviation for each machine, and the data from the contingency day is shown in Table 7.5.

Table 7.5: Between run standard deviation for contingency day (day 3)

Machine number	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
8	3.4	3.6	6.2	10.4	2.7	6.6
9	4.0	5.8	2.8	4.7	4.7	4.6
10	1.0	3.7	3.5	3.9	10.9	4.2
14	3.7	3.4	4.8	8.3	6.8	6.7

It can be seen from Table 7.5 that despite some variation in the values, no machine was obviously more variable on average than the others.

7.3.2 Mean deflection values

Table 7.6 shows the mean deflections recorded on each section, together with summary statistics for the contingency day. Instances where the between equipment standard deviation (BESD) is within the criterion are highlighted in green and instances where the criterion are not met are in red. Table 7.7 shows the deviations from the overall mean and these are highlighted if they are more than 2 or 3 times the BESD criteria (orange and red respectively).

Table 7.6: Mean deflection (µm) by section: Contingency day

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
8	55	57	210	188	138	148	134	131
9	32	28	202	155	112	104	115	96
10	59	55	218	187	138	146	138	129
14	65	56	221	168	153	130	146	118
Mean	53	49	213	175	135	132	134	118
BESD	14.2	14.3	8.9	15.6	16.9	20.4	13.1	16.3
BESD criterion	11.2	11.1	15.3	14.4	13.4	13.3	13.3	12.9
CoV	27.0%	29.2%	4.2%	8.9%	12.5%	15.4%	9.8%	13.7%

Table 7.7: Deviation (µm) from overall mean deflection by section: Contingency day

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
8	2.2	8.2	-3.0	13.1	2.9	16.1	0.7	12.5
9	-20.4	-21.4	-11.1	-19.0	-23.2	-28.2	-18.2	-22.8
10	6.0	6.3	5.5	12.4	2.7	13.7	4.7	10.8
14	12.2	6.8	8.6	-6.5	17.5	-1.7	12.8	-0.4
2x BESD criterion	22.5	22.3	30.7	28.7	26.7	26.5	26.6	25.8
3x BESD criterion	33.7	33.4	46.0	43.1	40.1	39.8	39.9	38.8

From Table 7.6 it can be seen that the BESD criteria is not met in most cases. This would typically mean that this spread is unsuitable. However, this is a subset of the fleet which might not reflect the average of the whole fleet and the nature of the criteria means that it is harder to meet with fewer machines.

7.3.3 Comparison with main trial day

In order to combine the data from the two days, the average deflection values calculated using the machines that acted as a reference on the contingency day (8, 10 and 14) was calculated for each section and each wheel path on each day. The ratios between the values for the two days (for each section and wheel path) were then calculated and applied to the data from Machine 9 collected on the contingency day. This allowed a more realistic estimate of the likely deflections it would have measured if it had operated in its new configuration on the main trial day.

The average from each day for the machines acting as reference and the calculated ratios are show in Table 7.8.

Table 7.8: Reference data values and estimation ratio

	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
Average main trial day	61	54	268	223	165	160
Average contingency day	59	56	216	181	143	141
Ratio	1.03	0.96	1.24	1.23	1.15	1.13

From this data it can be seen that the deflections were similar on HECP_01 on both days but were lower on the contingency day on the other two sections. Further examination of the data showed that, in general, the machines appeared to be performing consistently between each of the days relative to each other.

Table 7.9 shows the mean deflections recorded on each section for the combined dataset.

Table 7.10 shows the deviations from the overall mean. In both of these tables Machine 9 is in blue italic text to highlight that it is an estimate.

Table 7.9: Mean deflection (µm) by section: Combined dataset

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	57	58	261	235	161	164	160	152
3	30	41	239	212	125	128	131	127
5	54	44	258	204	163	145	158	131
8	61	54	263	229	161	162	162	148
9 (estimate)	*33*	*27*	*250*	*192*	*129*	*117*	*137*	*112*
10	55	51	257	223	153	159	155	144
12	51	46	261	199	149	139	154	128
14	68	57	283	218	181	158	177	144
15	56	54	257	203	156	143	156	133
16	60	58	268	222	161	151	163	144
Mean	52	49	260	214	154	146	155	136
BESD	11.8	9.8	11.5	14.0	16.4	15.4	12.9	12.4
BESD criterion	11.2	11.1	16.6	15.4	13.8	13.6	13.9	13.4
CoV	22.6%	20.1%	4.4%	6.6%	10.7%	10.5%	8.3%	9.1%

Table 7.10: Deviation (µm) from overall mean deflection by section: Combined dataset

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	4.7	8.7	1.5	21.6	7.5	17.2	4.6	15.8
3	-22.2	-7.4	-20.6	-1.8	-28.9	-19.0	-23.9	-9.4
5	1.5	-5.2	-2.0	-9.5	9.1	-1.6	2.8	-5.4
8	8.2	5.3	3.3	15.3	7.0	15.4	6.2	12.0
9 (estimate)	*-19.3*	*-22.3*	*-10.1*	*-21.8*	*-24.5*	*-29.3*	*-18.0*	*-24.5*
10	2.7	2.3	-2.3	8.9	-0.7	12.1	-0.1	7.8
12	-1.4	-3.3	1.0	-14.9	-5.2	-7.7	-1.9	-8.6
14	15.3	7.7	23.4	4.3	26.8	12.0	21.8	8.0
15	3.3	5.0	-2.7	-10.6	2.2	-3.6	1.0	-3.1
16	7.1	9.1	8.6	8.5	6.8	4.6	7.5	7.4
2x BESD criterion	22.5	22.3	33.1	30.7	27.7	27.3	27.7	26.8
3x BESD criterion	33.7	33.4	49.7	46.1	41.5	40.9	41.6	40.2

It can be seen from these two tables that the BESD criteria is met for the average of the site. The criteria is not met for HECP_03 or for the NS wheel path for HECP_01. It can also be seen (

Table 7.10) that all machines are within 3 times the BESD criterion of the fleet mean. One machine (Machine 3) is between 2 and 3 times the BESD criterion on one section (HECP_03) for the NS measurement. Another machine (Machine 9) is between 2 and 3 times the BESD criterion on two sections (HECP_01 and HECP_03) for the OS measurement.

Therefore following this additional testing all ten machines are considered as meeting the trial criteria for deflection measurement.

8 Conclusions

The 2019 National Deflectograph accreditation trials were held on the Horiba-MIRA proving grounds by TRL on behalf of Highways England during the period 5th to 7th March 2019. Ten of the machines in the current UK fleet attended the trial.

The following conclusions were drawn in relation to the various mandatory tests and assessments:

(I) Wheel Weights

Five of the ten machines exceeded the front axle limits defined in HD29/08 (Design Manual for Roads and Bridges, 2008). Following a review of this matter in 2004, machines exceeding the front axle weight limits are regarded as acceptable provided that they perform satisfactorily in the dynamic tests. All of the machines were within the rear wheel weight limits.

(II) Deflection measurement

After additional testing all ten machines that participated in the 2019 trial met the criteria for deflection measurement.

(III) Distance measurement

All ten machines that participated in the 2019 trial met the criteria for distance measurement.

The following conclusions were drawn in relation to the various additional tests and assessments:

(IV) Temperature measurement – measurement at depth

At the completion of the trial, nine of the ten operators achieved a high performance with regards to the measurement of temperature at depth. The remaining operator achieved a medium performance.

(V) Temperature measurement – surface temperature

Surface temperature data from four machines was supplied at this trial. One machine achieved a high performance with regards to the measurement of surface temperature. The remaining three achieved a medium performance.

(VI) Temperature measurement – air temperature

Air temperature data from four machines was supplied at this trial. This data was assessed using the surface temperature criteria. All four machines achieved a high performance with regards to the measurement of air temperature.

A summary of the machines that attended the 2019 accreditation trial and the criteria that they met/performance achieved can be found in Appendix A.

References

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Appendix A Machine identification

Table A.1: Machine identification

ID	Operator at trial date	Registration number	Performance achieved				
			Deflection	Distance	Temperature		
					At 40mm	Surface	Air
2	PTS Ltd	L697 BKR	Pass	Pass	High	Not assessed	Not assessed
3	TRL Ltd	B180 FBL	Pass	Pass	High	Not assessed	Not assessed
5	WDM Ltd	D962 JRU	Pass	Pass	High	Not assessed	Not assessed
8	WDM Ltd	BYW 80V	Pass	Pass	High	Medium	High
9	WDM Ltd	VGV 182X	Pass	Pass	High	High	High
10	WDM Ltd	F569 JBB	Pass	Pass	High	Medium	High
12	WDM Ltd	EOU 230W	Pass	Pass	High	Not assessed	Not assessed
14	Lincolnshire County Council	B195 CFW	Pass	Pass	Medium	Not assessed	Not assessed
15	DoE Northern Ireland	ACZ 3268	Pass	Pass	High	Not assessed	Not assessed
16	WDM Ltd	B880 XOU	Pass	Pass	High	Medium	High

Appendix B Layout of test sections at Horiba-MIRA

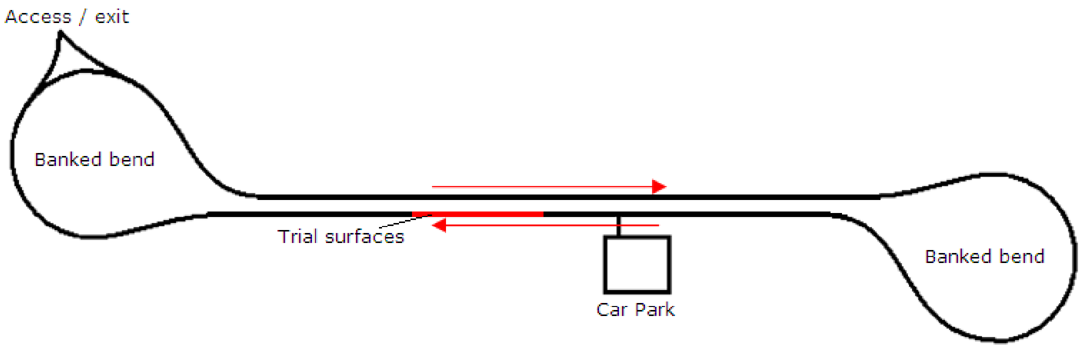

Figure B.1: Test route on the Horiba-MIRA twin straights

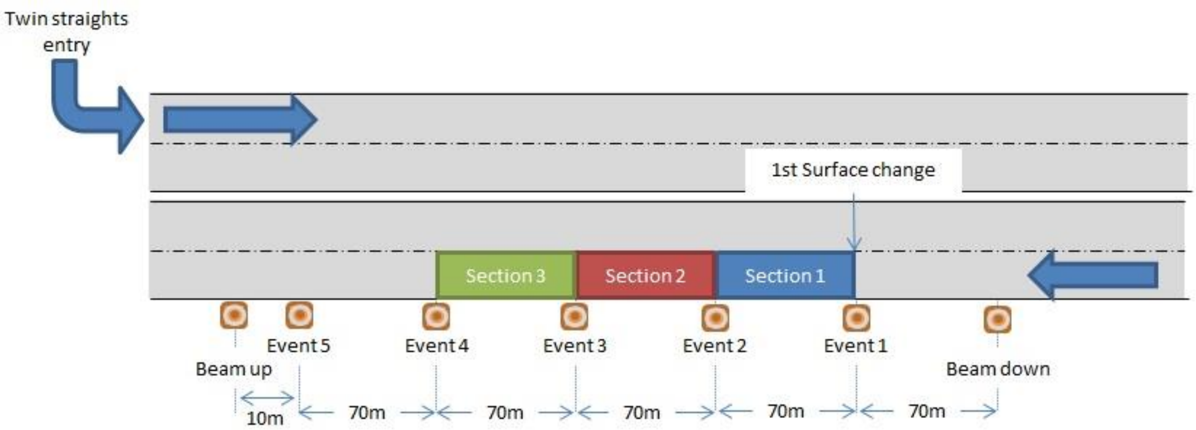

Figure B.2: Location of marker cones and test sections on Horiba-MIRA twin straights

Appendix C Construction details for Horiba-MIRA test sections

Table C.1: Design construction of Horiba-MIRA site

Section	Nominal construction details and material type (mm)			
	Surface course	Binder course	Total asphalt thickness (mm)	Sub-base
HECP_01	30 TSC	235 EME2	270	200mm C8/10 HBM
HECP_02	35 TSC	170 DBM	200	250mm 6F1 granular capping material
HECP_03	30 TSC	170 EME2	200	200 Type 1 granular material

Notes: TSC = Cl 942 Thin Surface Course EME2 = Enrobé à Module Élevé, DBM = Dense Bitumen Macadam, HBM = Hydraulically Bound Material, 6F1 = Selected granular capping.

Table C.2: Construction details for Horiba-MIRA site from cores

Section	Post Construction Results from cores (mm)			
	Surface course	Binder/ Binder+ base courses	Total asphalt thickness (mm)	Base (mm)
HECP_01	42 TSC	228	270	217 (HBM)
HECP_02	37 TSC	158	192	-
HECP_03	35 TSC	191	226	-

Notes: TSC = Cl 942 Thin Surface Course EME2 = Enrobé à Module Élevé, DBM = Dense Bitumen Macadam, HBM = Hydraulically Bound Material

Table C.3: Construction details for Horiba-MIRA site from GPR

Section	Post Construction Results from cores (mm)			
	Minimum	Average	Maximum	Material
HECP_01	192	242	272	Asphalt
	166	188	215	HBM
	388	431	468	Total bound thickness
HECP_02	167	192	240	Asphalt
HECP_03	167	199	240	Asphalt

Notes: HBM = Hydraulically Bound Material

Highways England 2019 National Deflectograph Accreditation Trial

A key element for the successful maintenance of a road network is accurate, reliable and consistent survey data. To this aim, Highways England commissions annual accreditation trials for the Deflectograph devices supported by ongoing QA for the devices. In order to undertake accredited surveys, the survey devices are required to meet the mandatory criteria of the trial.

This report covers the 2019 accreditation trial run by TRL and held on the HORIBA-MIRA proving ground between 5th and 7th March 2019.

Other titles from this subject area

PPR939	Highways England 2018 National Deflectograph Accreditation Trial. S Brittain. 2020
PPR941	Highways England 2017 National Deflectograph Accreditation Trial. S Brittain. 2020
PPR942	Highways England 2016 National Deflectograph Accreditation Trial. S Brittain. 2020
PPR943	Highways Agency 2015 National Deflectograph Accreditation Trial. S Brittain. 2020

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

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