THE FUTURE OF TRANSPORT

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Highways England 2021 National Deflectograph Accreditation Trial

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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) and other road networks. 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 2021 trial was held from the 23rd to the 25th February 2021. The site used was the twin horizontal straights of the Horiba-MIRA proving ground. This was the twenty-sixth year in which TRL have taken full responsibility for the planning and running of the trials. Ten machines attended the trial which represents the entirety of the known UK fleet.

The format of the 2021 trial followed a different procedure to previous years due to changes made to mitigate risks from COVID-19. These changes allowed for increased safety for all staff on site while maintaining the same tests and assessments as in previous years. The first day of the trial was used to undertake vehicle weighing and distance calibrations followed by tests by the machines of the site. No testing was undertaken on the second day of the trial as this time was used to process the data and provide operators the opportunity to make adjustments to their devices based on the feedback received. The third day was used to repeat the assessment of the devices to assess any changes undertaken.

Nine of the ten machines that participated in the 2021 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.

With regards to the measurement of pavement temperature at depth, two of the ten machines achieved a “high” performance rating and the remaining eight a “medium” performance rating.

For the 2021 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. All four machines achieved a medium performance with regards to the measurement of surface temperature. Three machines achieved a high performance with regards to the measurement of air temperature and one achieved a medium performance.

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 can be assessed.

The 2021 trial was held from 23rd to the 25th February 2021. 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-sixth year in which TRL have taken full responsibility for the planning and running of the trials and the ninth full trial at Horiba-MIRA. Ten machines attended the trial. The trial process and the criteria used for the 2021 trial are discussed in Section 3 and Appendix D of this report, respectively. The results from the trial are discussed in Sections 4 to 8.

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. They are 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) in 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 Appendix B. Nominal construction details of the test sections can be found in Appendix C.

2.2 Suitability of site and management of site dependent between run variability

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.

During the transitional trial it was found that there was a localised high deflection area on the site. This caused an increase in the between run variability in the data due to small changes in driving line. This was further investigated at the 2013 trial and it was found that this variability could be removed by placing small cones 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 2.1), so that any deviation in the test line would cause a cone to be knocked over and thereby any deviation could be recorded. This approach was repeated for the 2021 trial.

Figure 2.1: Image illustrating cone positions during testing

3 Trial format

The format of the 2021 trial varied from recent years due to changes made to mitigate risks from COVID-19. The format applied to this trial is described in this section.

Each crew carries out a machine inspection in advance of the trials and a certified checklist is submitted before the machine is included in the running trials.

3.1 Day 1 – Weighing, distance calibration and test laps

On arrival, all staff sign in at the Horiba-MIRA Gatehouse. They then report in to the TRL reception staff, where they are given their documentation and instructions for the day. When all participants have arrived a briefing is given by TRL to ensure that the testing is completed safely and correctly.

After the morning briefing, each machine undergoes a distance calibration and is weighed to determine the loads applied by each wheel to the road surface. These wheel weight values are then used in the trial software to allow corrections for rear wheel weight to be applied to the deflection data.

Once this process is complete, each machine undertakes a static calibration followed by a familiarisation lap (measuring deflection only) and then at least 5 test laps (measuring deflection, temperature measurement and distance travelled check).

The machine running order is randomised and all machines complete the testing in convoy (with suitable gaps left between them) to cover all the sections in a single measurement run.

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.

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.

CS229 (DMRB CS 229, 2020) sets a maximum rate of temperature increase of 2.5˚C per hour at 40mm for deflection testing on the UK 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 pavement 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 observe the dynamic operation of each machine, including a timed section in order to verify that operating speeds are acceptable.

Survey data collected is e-mailed/transferred via FTP back to the TRL office and processing and interpretation of the data is done offsite (to minimise the risk of spreading COVID to or from staff on the test track.

3.2 Day 2 – Data processing and machine alterations

The morning of this day is used to finish of the processing and interpretation of data collected on day 1. The conclusions from the testing on day 1 are provided to the participants of the trial (via e-mail) no later than 13:00 on this day.

The twin straights test site are made available to participants from 09:00 to 18:00 to allow contractors to undertake maintenance adjustments if required and to complete any additional testing that they wish to perform. Data collected from this additional testing is not reviewed by TRL.

3.3 Day 3 – Additional test laps

If any machines fail to meet the criteria set (or undergo alterations after Day 1 testing) then all devices would return to undertake test laps on Day 3. The nature of the testing on this day will depend on the performance of the devices on day 1.

4 Day 1 (23rd February 2021) – Inspections, weights and familiarisation lap

4.1 Inspections

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

4.2 Wheel weights

In previous trials, the Deflectographs have been weighed in the maintenance building on the HORIBA-MIRA proving ground. However, during the 2020 trial a member of staff slipped over during this process raising questions on the suitability of the location for this process. Therefore, for the 2021 trial it was decided that the possibility of making these measurements on the twin straights be investigated.

It is known that this site can experience high levels of wind, but a possible location for these measurements was identified prior to the trial. Due to the uncertainty of whether it would be possible to make accurate measurements at this location, data collected by the device manufacturer during the winter services of these devices (and a separate measurement for machine 3 which did not have a service this year) were used for the trial and are given in Table 4.1. To aid comparison to the criteria, the percentage of the target weight (100% corresponds to matching the target) are shown in brackets beneath the Total front, Rear NS and Rear OS values. If any machines were outside of the criteria then they would be highlighted in bold red text.

Table 4.1: Deflectograph weights from winter service/measurement before trial

Machine	Weight distribution including crew (kg)						
	Front NS	Front OS	Total Front	Rear NS	Rear OS	Total rear	Total Machine
2	2450	2602	5052 (112.3%)	3122 (98.3%)	3280 (103.3%)	6402	11454
3	2402	2502	4904 (109%)	3324 (104.7%)	3339 (105.1%)	6662	11566
5	2264	2342	4606 (102.4%)	3118 (98.2%)	3208 (101%)	6326	10932
8	2238	2416	4654 (103.4%)	3092 (97.4%)	3280 (103.3%)	6372	11026
9	2342	2310	4652 (103.4%)	3358 (105.8%)	3230 (101.7%)	6588	11240
10	2384	2344	4728 (105.1%)	3424 (107.8%)	3198 (100.7%)	6622	11350
12	2210	2386	4596 (102.1%)	3334 (105%)	3214 (101.2%)	6548	11144
14	2332	2338	4670 (103.8%)	3144 (99%)	3424 (107.8%)	6568	11238
15	2428	2532	4960 (110.2%)	3362 (105.9%)	3340 (105.2%)	6702	11662
16	2262	2324	4586 (101.9%)	3140 (98.9%)	3258 (102.6%)	6398	10984

All machines are within the front axle and rear wheel limits given in the Accreditation and QA specification (TRL, 2020).

4.2.1 Weight measurements made on twin straights

A set of weigh pads was set-up on the twin straights so that the machines could be weighed in convoy. The location chosen appeared to be relatively sheltered against the wind and the process ran smoothly. The purpose of this work was to identify if this approach would be suitable to carry out at future trials. To keep the impact of this work on the main testing of the trial low, it was decided that only one measurement would be undertaken for each machine.

The values obtained were broadly consistent with those collected before the trial, and the differences are likely to have been even smaller if additional measurements were taken (and the average value used). Another consideration is that at this trial wind levels were not as high as some previous experience at the site. Therefore, it is recommended that at future trials multiple measurements of wheel weight are conducted for each machine and the average (after any particular outliers are removed) are used. The number of measurements taken may depend on how variable the values are on the day. In addition to this, consideration should be given to alternative options for obtaining weight values if it is too windy on the first day of the trial.

4.3 Beam calibration check

Prior to the familiarisation lap, 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 the accreditation and QA specification (TRL, 2020).

4.4 Familiarisation lap

To allow the machines to “warm up”, the deflection data collected on the familiarisation lap was disregarded (after analysis for any obvious issues). Analysis of the data from this lap did not identify any conclusions inconsistent with the remaining laps on this day.

5 Day 1 (23rd February 2021) – Results of test laps

5.1 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 513m. 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 reviewing the survey file and identifying the length between the two marker points. The crews were also asked to provide these survey files.

The difference between the measured length from each machine and the reference length, along with the overall performance, are given in Table 5.1. If the difference between the machine and the reference exceeds the threshold for the criteria as set out in Section D.1, it would be highlighted in red.

It was not possible to complete all of the distance measurements on day 1 of the trial and as such some were collected on day 2 or 3. However, the same measurement length was used in all cases so the data has been collected together here into a single table for ease of reporting.

Table 5.1: Distance measurement results

Machine	Difference between measured length and the reference (m)					% within criteria	Performance
	1	2	3	4	5		
2	2.0	-1.0	-1.0	-4.0	-1.0	100	Pass
3	-4.0	-2.0	-4.0	-5.0	-1.0	100	Pass
5	1.0	0.0	-3.0	0.0	-2.0	100	Pass
8	-3.0	-5.0	-2.0	-1.0	0.0	100	Pass
9	-5.0	-1.0	-1.0	-3.0	-3.0	100	Pass
10	0.0	-1.0	0.0	0.0	-2.0	100	Pass
12	0.0	-4.0	-4.0	-2.0	-2.0	100	Pass
14	1.0	1.0	-2.0	-3.0	-3.0	100	Pass
15	2.0	-1.0	0.0	0.0	-1.0	100	Pass
16	-2.0	0.0	1.0	-2.0	-2.0	100	Pass

From Table 5.1 it can be seen that all ten machines passed the distance measurement criteria.

5.2 Temperatures

5.2.1 Temperatures recorded by the data loggers

Data loggers connected to thermocouples recorded 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 5.1 and Figure 5.2.

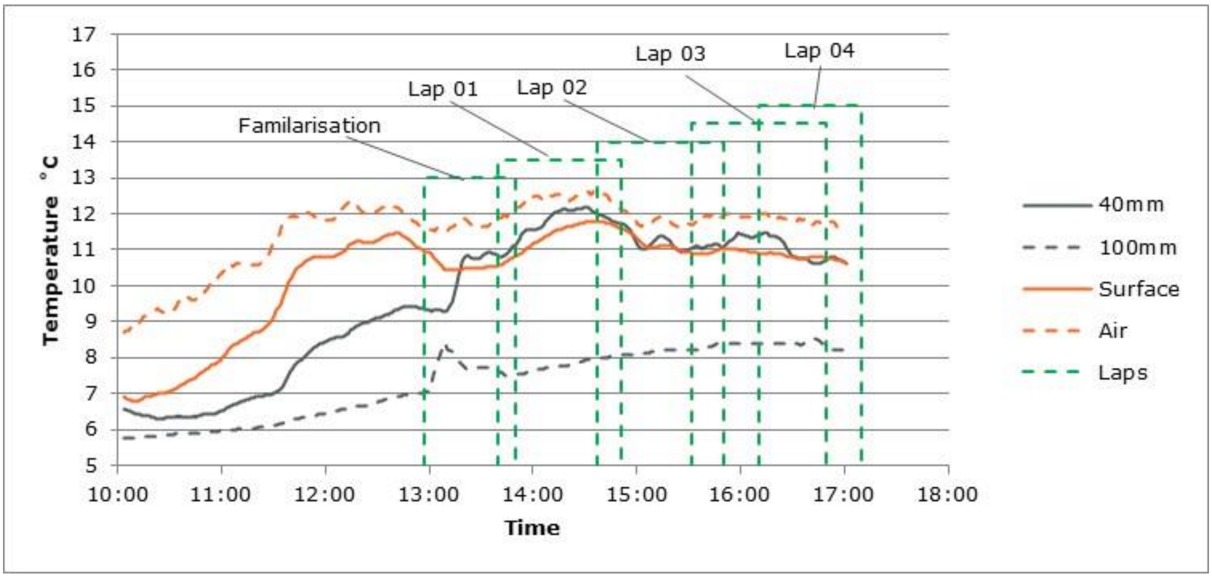

Figure 5.1: Temperature measurements from temperature station 1 (before test sections)

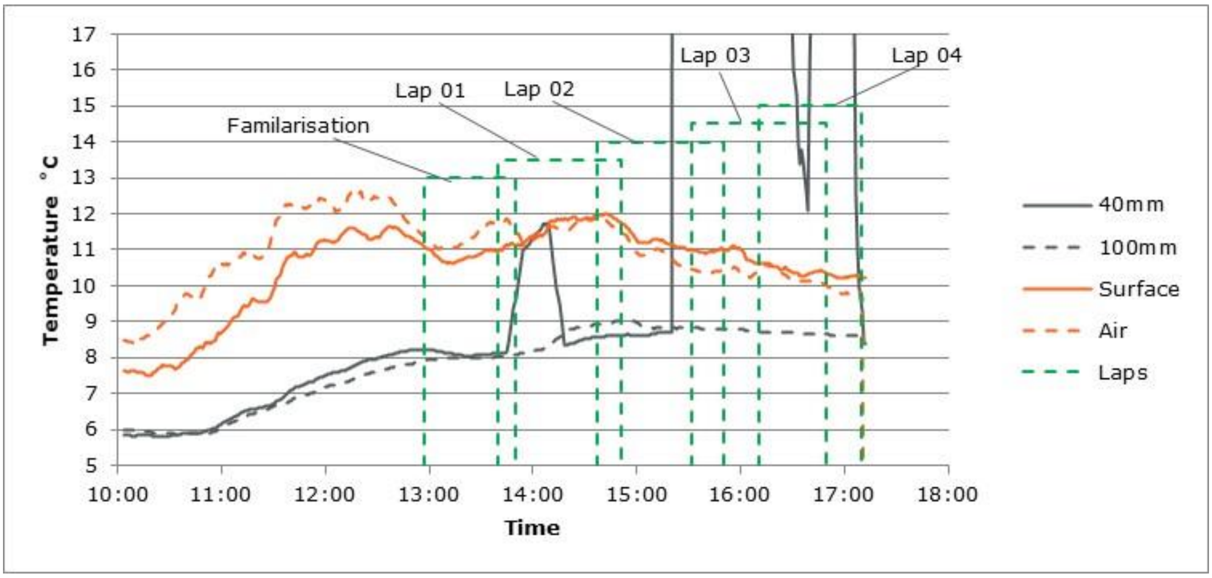

Figure 5.2: Temperature measurements from temperature station 2 (after test sections)

Looking at the data for station 2 it can be seen that the 40mm data changes significantly up and then down around 14:00 and even further up after 15:30. It is unknown what happened in these instances but it may be that the thermocouple was dislogged from the hole – whatever happened this data was obviously erroneous. Excluding this data it can be seen that in general the graphs show a steady increase in temperatures before the test laps. This was then followed by relatively stable temperatures for the remainder of the day (with a slight dip towards the end of the testing).

Due to the anomaly with the logger data for the 40mm on temperature station 2, it was decided that the assessment of the operators' temperature measurements would be undertaken on the data collected on day 3.

5.3 Deflection readings

During day 1, five laps of the test sections were conducted (a familiarisation lap and laps 1-4). However, the first lap (the familiarisation lap) was disregarded (after analysis) to allow the machines to warm-up. One machine (Machine 05) broke down on its way to the trial and was unable to take part in the testing on this day. In addition, due to some issues with transferring data from one of the survey contractors the test laps took longer than expected. This meant that Machine 15 (which was the last machine in the test lap) was unable to complete lap 4 within the time allowed on the track. Therefore, in the tables and analysis below the data for Machine 15 is calculated from 3 laps and for the other machines it is calculated from 4 laps.

5.3.1 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 (BRSD) for each machine, as shown in Table 5.2.

Table 5.2: Between-run standard deviation for day 1 (3 laps for machine 15, 4 laps for the remainder)

Machine number	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
2	4.8	2.4	9.3	2.3	3.8	4.4
3	6.4	2.1	**38.1**	10.6	13.4	8.7
5	-	-	-	-	-	-
8	4.9	1.8	5.2	4.0	7.6	3.8
9	5.1	2.9	9.0	8.8	6.1	6.3
10	4.1	5.0	14.2	15.5	6.7	3.8
12	4.8	1.4	6.0	9.4	11.8	3.0
14	1.8	1.0	1.7	2.9	14.2	8.7
15	3.4	2.6	7.3	4.0	3.2	2.1
16	1.5	2.4	6.7	1.6	7.2	5.1

It can be seen from Table 5.2 that Machine 3 is producing noticeably higher BRSD for the NS measurements for the HECP_02 section. The BRSD for the NS measurements for this machine are also slightly raised on the other two sections. No other machines were identified as significant outliers.

5.3.2 Mean deflection values

Table 5.3 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. This table is used to identify if the overall fleet distribution is suitable. Table 5.4 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). This table helps to identify if any machines are significant outliers and provide further information on the distribution of the fleet if the spread is unsuitable.

Table 5.3: Mean deflection (µm) by section: day 1 (3 laps for machine 15, 4 laps for the remainder)

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	47	36	238	190	126	110	137	112
3	34	33	183	178	91	102	102	105
5	.	.	.	.	.	.	.	.
8	45	48	225	201	122	124	130	124
9	47	54	230	212	117	130	131	132
10	57	52	262	217	143	145	154	138
12	36	42	216	193	115	125	123	120
14	55	43	247	194	148	118	150	118
15	49	47	255	210	136	125	147	127
16	54	47	262	208	150	130	155	128
Mean	47	45	235	200	128	123	137	123
BESD	8.0	6.8	25.6	12.8	19.0	12.1	17.2	10.3
BESD criterion	11.1	11.0	15.9	15.0	13.2	13.0	13.4	13.0
CoV	16.9%	15.3%	10.9%	6.4%	14.9%	9.8%	12.6%	8.4%

Table 5.4: Deviation (µm) from overall mean deflection by section: day 1 (3 laps for machine 15, 4 laps for the remainder)

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	-0.2	-8.5	2.9	-10.0	-1.7	-13.1	0.3	-10.6
3	-13.4	-11.4	-52.7	-22.5	-37.1	-20.7	-34.4	-18.2
5	.	.	.	.	.	.	.	.
8	-2.3	3.0	-10.5	0.7	-5.7	0.9	-6.2	1.6
9	0.2	9.1	-5.5	12.0	-10.2	6.8	-5.2	9.3
10	9.8	7.4	26.8	16.9	15.7	21.5	17.5	15.3
12	-10.7	-2.9	-18.9	-7.8	-12.2	1.5	-13.9	-3.1
14	8.2	-1.7	11.4	-6.9	20.4	-4.9	13.3	-4.5
15	1.8	2.5	19.7	10.0	8.7	1.6	10.1	4.7
16	6.7	2.4	26.7	7.7	22.1	6.3	18.5	5.5
2x BESD criterion	22.2	22.0	31.9	30.1	26.3	26.1	26.8	26.1
3x BESD criterion	33.3	33.1	47.8	45.1	39.5	39.1	40.2	39.1

From Table 5.3 it can be seen that the BESD criteria is met for the average of the site (and all three sections) for the OS wheel path. However, it is not met for the average of the site for the NS wheel path. In addition, from Table 5.4 it can be seen that Machine 03 is more than 3 times the BESD criterion from the fleet mean on section 2 (which is an automatic fail criteria), and between 2 and 3 times the criterion for both section 3 and the overall average for the site.

Therefore, Machine 03 has been identified as an outlier. If this machine is excluded from the analysis then the BESD criteria is met for the average of the site for both wheel paths as shown in Table 5.5. In addition, all remaining machines are within 2 times the BESD criterion from the fleet mean.

Table 5.5: Fleet distribution statistics for day 1 after exclusion of Machine 03

Statistic	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
Mean	49	46	242	203	132	126	141	125
BESD	6.6	5.7	17.4	10.2	13.9	10.0	12.2	8.2
BESD criterion	11.1	11.1	16.1	15.1	13.3	13.1	13.5	13.1
CoV	13.6%	12.4%	7.2%	5.0%	10.5%	7.9%	8.6%	6.6%

As discussed in section 5.3.1, Machine 03 showed a high between run standard deviation, with the last two runs producing much lower readings than the first two runs with this machine. This information was provided to the crew of Machine 03 so that they could investigate their device before taking part in the testing on day 3.

6 Day 2 (24th February 2021) – Feedback to operators and machine alterations

The data from day 1 was processed and feedback on the performance was provided via e-mail at 10:45 on day 2. TRL provided access to the Horiba-MIRA facilities to allow Machine 03 to investigate its performance and make alterations.

As previously mentioned, Machine 05 broke down on its way to the trial and was unable to take part in the testing on day 1. This machine was also on the Horiba-MIRA facilities on this day to check the performance of their machine before the testing on day 3.

Some additional machines were on site on this day to carry out the distance check assessments (see section 5.1).

7 Day 3 (25th February 2021) – Results of additional test laps

7.1 Beam calibration check

Prior to the testing on this day 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 the accreditation and QA specification (TRL, 2020).

7.2 Temperatures

7.2.1 Temperatures recorded by the data loggers

The loggers were set up and processed on day 3 in the same manner as day 1 (see 5.2.1 for further details). The smoothed data from day 3 is shown in Figure 7.1 and Figure 7.2.

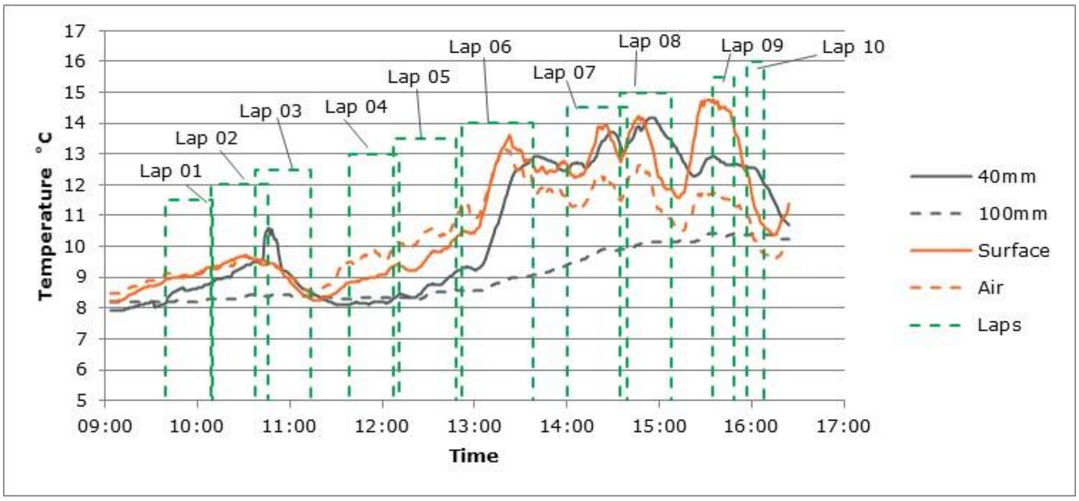

Figure 7.1: Temperature measurements from temperature station 1 (before test sections)

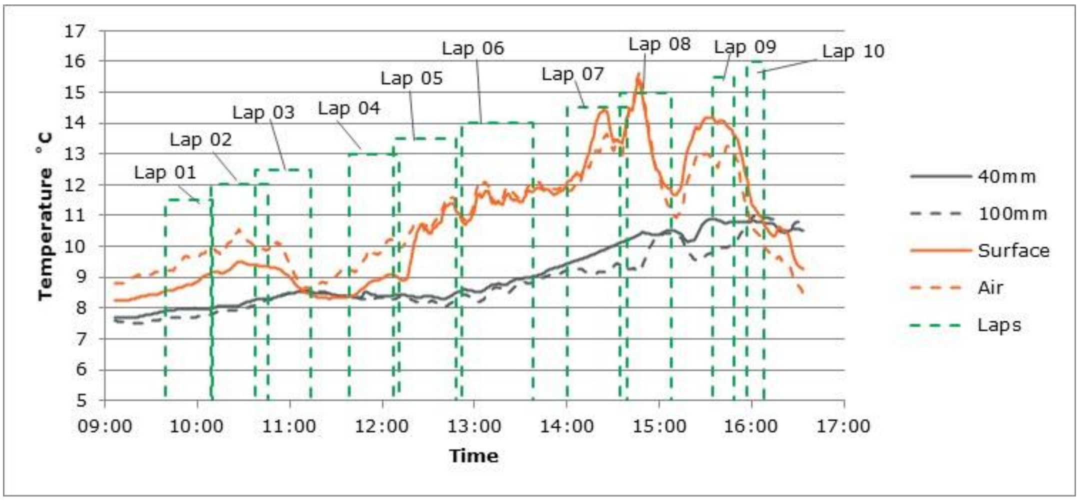

Figure 7.2: Temperature measurements from temperature station 2 (after test sections)

During Day 3 temperatures were relatively stable in the morning and then increased in the afternoon.

As discussed in Section 3.1, CS 229 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 7.3.

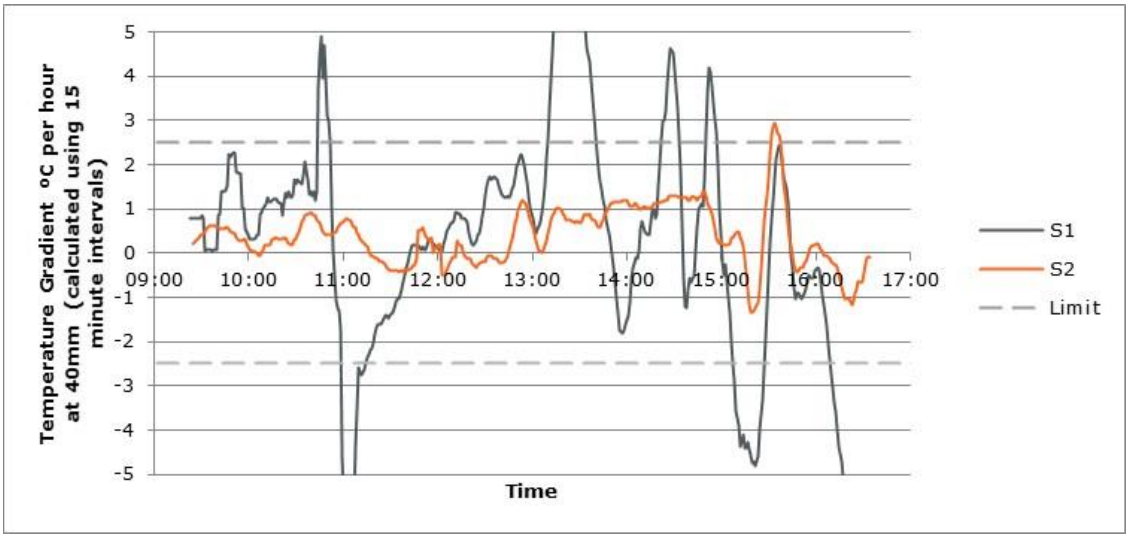

Figure 7.3: 40mm depth temperature changes day 3

It can be seen from Figure 7.3 that the rate of change in temperature is within the limits for the majority of the day, particularly for station 2. The majority of instances where the change is outside of the limits occurs mainly for Section 1 and where there is both a positive and negative change in temperature in quick succession. These are likely caused by the logger thermocouples being incorrectly removed from the hole during the operators' measurements of the hole. There is one instance where this does not look like the case which is at 13:30 on station 1 where a different pattern of variation is seen. Therefore the data collected at this time (lap 06) may be subject to additional variability.

7.2.2 Temperatures at depth, recorded by operators

The Deflectograph crews made measurements of temperature from the two temperature test stations at a 40mm depth (in the path). This data is shown in Figure 7.4 and Figure 7.5.

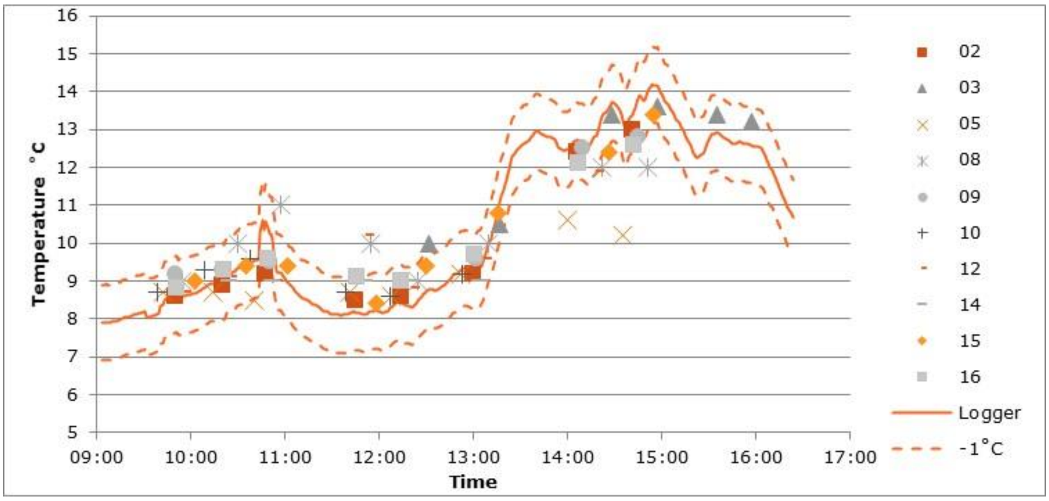

Figure 7.4: Comparison of operators' measurements against reference – Temperature test station 1, day 3

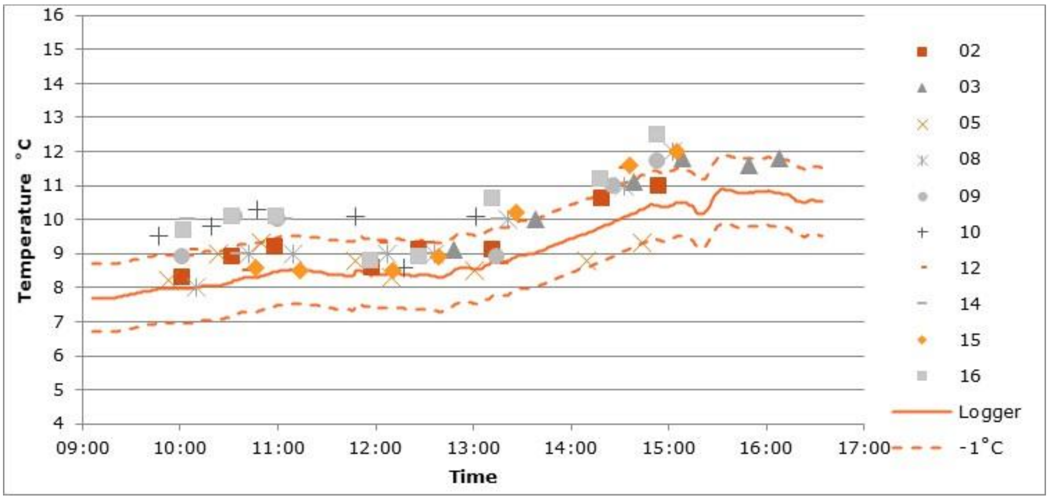

Figure 7.5: Comparison of operators' measurements against reference – Temperature test station 2, day 3

The differences between the operators' measured values and the reference values recorded by the loggers are shown in Table 7.1. If the recorded value is more than 1˚C away from the reference then it is highlighted in bold red text. Table 7.1 also shows the performance band awarded to each operator.

Table 7.1: 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	0.0	0.3	-0.1	0.7	-1.2	0.8	0.3	0.2	0.2	0.7	-0.1	0.4	91.7	High
3	1.2	0.6	1.4	1.0	-0.2	0.9	-0.6	1.3	0.5	0.8	0.6	1.0	66.7	Medium
5	0.4	0.2	-0.2	1.0	-1.0	1.0	0.6	0.4	0.3	-0.1	0.8	0.0	91.7	High
8	0.4	0.0	0.7	0.7	1.8	0.5	1.8	0.6	0.6	0.7	1.3	1.2	66.7	Medium
9	0.6	0.9	0.3	1.9	-0.9	1.5	.	0.1	-0.2	1.1	-0.9	1.3	63.6	Medium
10	0.6	1.5	0.5	1.7	0.1	2.0	0.6	1.7	0.4	0.2	0.8	1.6	58.3	Medium
12	0.1	1.1	0.0	0.2	2.1	0.9	0.5	0.9	0.8	-0.1	-0.9	1.5	75.0	Medium
14	0.3	2.0	-0.1	0.8	-1.2	1.5	0.9	0.6	0.6	0.6	0.2	1.2	66.7	Medium
15	0.0	0.3	0.4	0.0	0.2	0.1	0.7	0.6	2.0	1.3	-1.1	1.5	66.7	Medium
16	0.3	1.9	-1.0	1.6	0.9	0.4	0.6	0.5	1.1	1.9	-0.6	1.5	58.3	Medium

Two machines achieved a high performance (Machines 2 and 5) and eight machines achieved a medium performance.

7.2.3 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. These are included in CS 229 (DMRB CS 229, 2020) which permits Deflectograph survey contractors to use air and surface temperature measurements to estimate 40mm pavement temperatures.

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 7.6 and Figure 7.7.

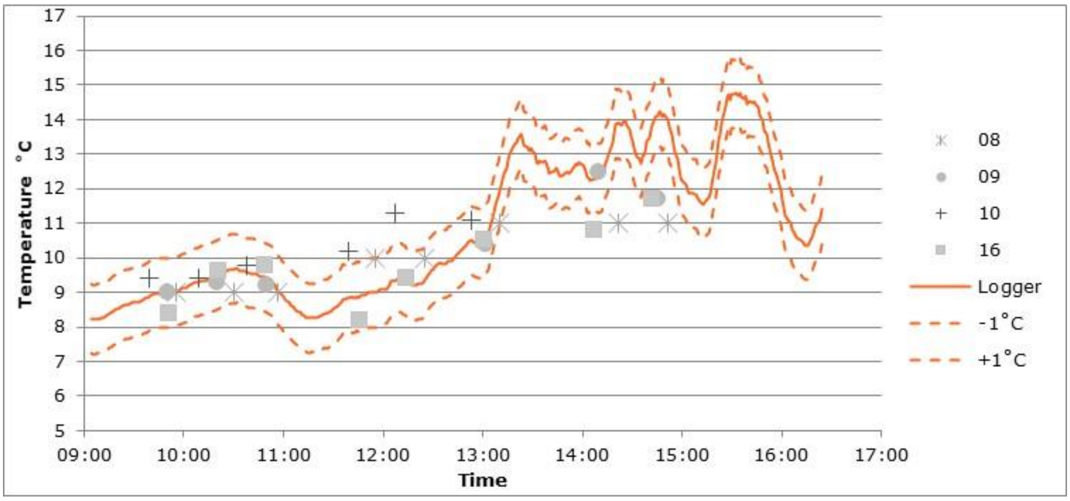

Figure 7.6: Comparison of Deflectograph recorded surface temperatures against reference – Temperature test station 1, day 3

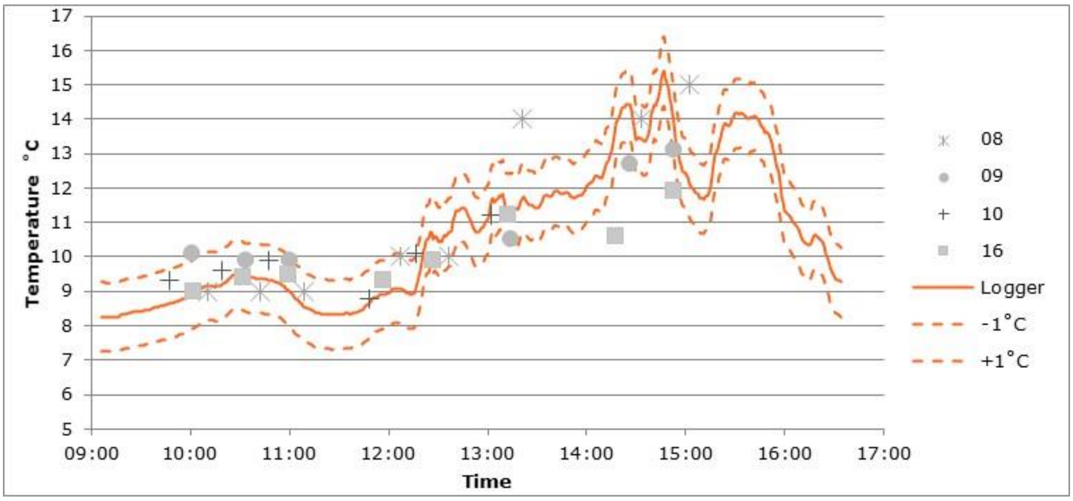

Figure 7.7: Comparison of Deflectograph recorded surface temperatures against reference – Temperature test station 2, day 3

The difference between the surface temperatures recorded by the Deflectographs and the reference are shown in Table 7.2 along with the awarded performance.

Table 7.2: Difference between operators surface temperature values and the reference

ID	Difference between measured temperature and reference (˚C)																% within criteria	Performance band
	Lap 1		Lap 2		Lap 3		Lap 4		Lap 5		Lap 6		Lap 7		Lap 8			
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2		
8	0.0	-0.2	-0.7	-0.4	-0.1	0.4	**1.0**	0.9	0.7	-0.6	-0.8	**2.4**	**-2.9**	0.6	**-3.1**	**2.7**	68.8	Medium
9	0.0	**1.2**	-0.2	0.5	-0.2	0.9	.	.	.	.	-0.1	-0.9	0.2	**-1.7**	**-2.4**	**-1.0**	66.7	Medium
10	0.6	0.7	0.1	0.4	0.2	0.6	**1.4**	0.2	**2.0**	**1.2**	0.6	-0.2	.	.	.	.	75.0	Medium
16	-0.6	0.1	0.1	-0.1	0.3	0.4	-0.7	0.4	0.0	-0.8	0.1	-0.3	**-1.5**	**-3.0**	**-2.0**	**-2.2**	75.0	Medium

All four machines achieved a medium performance.

The air temperatures from the logger and the data supplied from the operators is shown in Figure 7.8 and Figure 7.9.

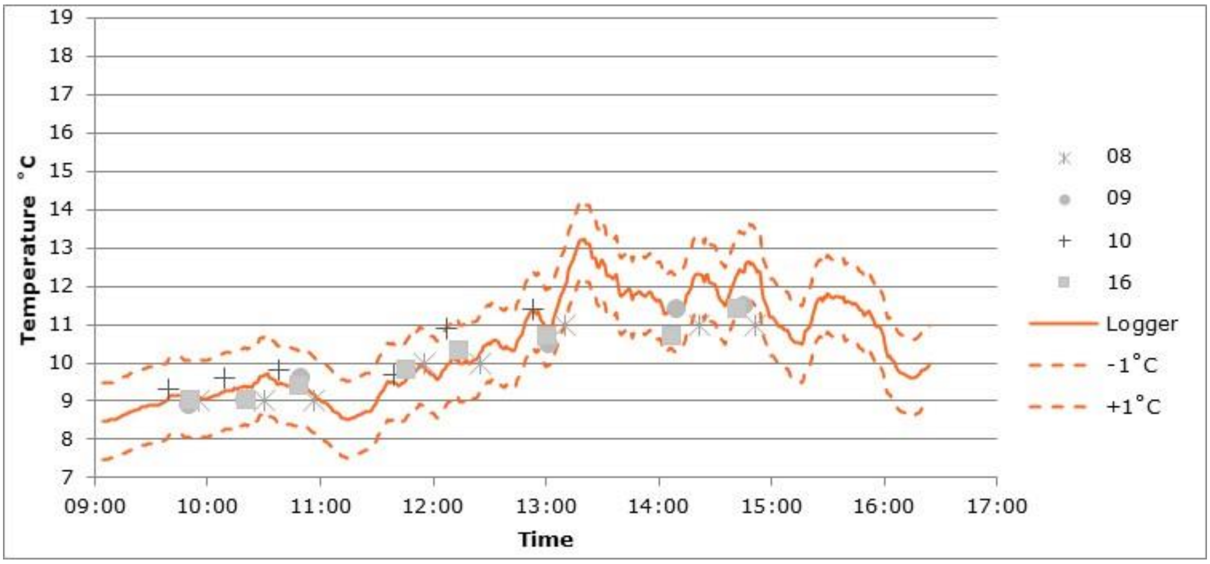

Figure 7.8: Comparison of Deflectograph recorded air temperatures against reference – Temperature test station 1, day 3

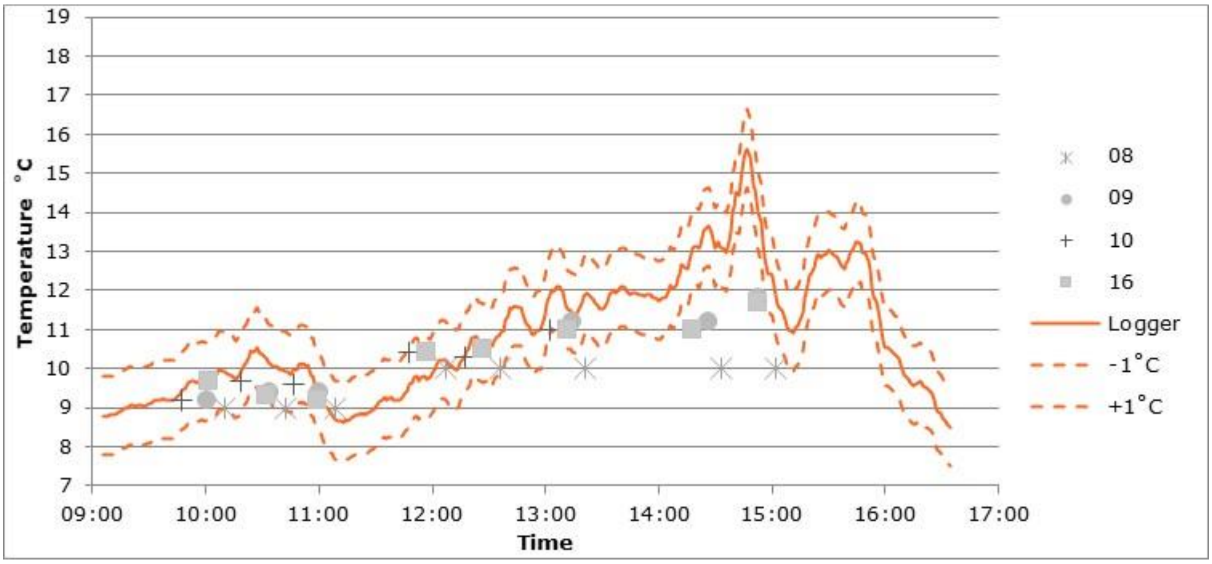

Figure 7.9: Comparison of Deflectograph recorded air temperatures against reference – Temperature test station 2, day 3

The difference between the air temperatures recorded by the Deflectographs and the reference are shown in Table 7.3 along with the performance awarded.

Table 7.3: Difference between operators' air temperature values and the reference

ID	Difference between measured temperature and reference (˚C)																% within criteria	Performance band
	Lap 1		Lap 2		Lap 3		Lap 4		Lap 5		Lap 6		Lap 7		Lap 8			
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2		
8	-0.1	-0.9	-0.7	-1.0	-0.2	0.3	0.1	-0.2	-0.2	-0.8	-0.9	**-1.8**	**-1.3**	**-3.1**	**-1.6**	**-2.1**	68.8	Medium
9	-0.2	-0.5	-0.4	-0.8	0.2	-0.1	.	.	.	.	-0.4	-0.3	0.1	**-2.4**	-0.9	**-2.5**	83.3	High
10	0.3	-0.2	0.4	-0.1	0.4	-0.3	0.2	0.9	**1.1**	0.1	0.0	-0.7	.	.	.	.	91.7	High
16	0.0	0.0	-0.4	**-1.0**	0.1	-0.4	0.3	0.6	0.2	-0.2	-0.2	-0.6	-0.7	**-1.9**	-0.9	**-2.6**	81.3	High

Three machines achieved a high performance and one machine achieved a medium performance.

7.3 Deflection readings

To allow the machines to "warm up", the first lap on this day was disregarded (after analysis). In addition, due to some issues with the alternator on Machine 03 it was unable to take part in the first 4 laps on this day. Therefore, the tables and analysis below include the data from laps 2 to 6 carried out on this day excluding Machine 03. Analysis of the data from Machine 03 is discussed in section 8.

7.3.1 Between-run standard deviation for deflection values

The between-run standard deviation (BRSD) for each machine, is shown in Table 7.4.

Table 7.4: Between-run standard deviation for day 3 (laps 2 to 6)

Machine number	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
2	3.9	3.1	9.3	10.2	7.9	6.5
5	2.1	1.6	2.4	5.1	13.1	13.2
8	1.0	2.3	5.5	6.5	7.9	10.3
9	7.3	5.2	7.5	8.8	11.2	13.6
10	2.7	2.6	7.2	15.2	9.6	12.2
12	1.7	3.7	12.6	7.2	7.5	6.1
14	1.6	3.2	8.6	9.0	11.3	6.2
15	3.5	3.2	8.2	10.5	11.6	6.9
16	1.9	1.8	5.4	6.2	11.7	8.1

It can be seen from Table 7.4 that despite some variation in the values, no machine was obviously more variable on average than the others.

7.3.2 Mean deflection values

The mean deflections recorded on each section, together with the summary statistics for the testing on day 3 (laps 2-6) can be seen in Table 7.5. As with the analysis for the data on day 1, 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 7.6 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 7.5: Mean deflection (µm) by section: day 3 (laps 2-6)

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	46	39	233	189	133	112	137	113
5	47	40	234	183	132	117	138	113
8	49	52	228	211	130	139	136	134
9	43	50	205	193	112	126	120	123
10	63	52	260	227	155	158	159	146
12	41	44	223	209	126	136	130	130
14	59	48	253	204	158	137	157	129
15	50	52	237	197	130	128	139	126
16	55	48	248	206	148	132	150	129
Mean	50	47	236	202	136	132	141	127
BESD	7.2	5.1	16.7	13.3	14.8	13.4	12.6	10.0
BESD criterion	11.2	11.1	15.9	15.1	13.4	13.3	13.5	13.1
CoV	14.4%	10.8%	7.1%	6.6%	10.9%	10.2%	9.0%	7.9%

Table 7.6: Deviation (µm) from overall mean deflection by section: day 3 (laps 2-6)

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	-4.3	-8.2	-2.9	-13.4	-2.7	-19.8	-3.3	-13.8
5	-3.3	-7.0	-1.5	-19.5	-3.8	-14.5	-2.9	-13.7
8	-1.0	4.8	-7.3	8.5	-5.6	7.0	-4.7	6.8
9	-6.9	3.1	-30.7	-8.6	-24.3	-5.3	-20.7	-3.6
10	12.3	4.7	23.9	24.9	18.8	26.3	18.4	18.6
12	-9.5	-3.4	-12.9	6.9	-10.2	4.5	-10.9	2.7
14	9.0	0.4	17.8	1.5	22.0	5.2	16.2	2.4
15	-0.5	4.9	0.9	-4.7	-5.7	-3.5	-1.8	-1.1
16	4.3	0.7	12.7	4.3	11.6	0.2	9.5	1.8
2x BESD criterion	22.3	22.2	31.9	30.1	26.7	26.5	27.0	26.3
3x BESD criterion	33.5	33.3	47.8	45.2	40.1	39.8	40.5	39.4

From Table 7.5 it can be seen that the BESD criteria is met for the average of the site in both wheel paths (and four of the six wheel path/section combinations). In addition, from Table 7.6 it can be seen that these nine machines are all within 2 times the BESD of the fleet mean in all instances. Therefore, these nine machines are considered as meeting the trial criteria for deflection measurement.

8 Investigation into deflection performance of Machine 03 on Day 3

As mentioned in section 7.3, due to issues with the alternator on Machine 03 it was unable to take part in the first 4 laps on day 3. The data collected by this machine on its first lap (lap 5 of day 3) was clearly an outlier as the values produced on sections 2 and 3 for the nearside were around half the fleet average. However, on their second lap (lap 6) the values were more consistent with the fleet.

Therefore, it was decided that additional testing would be conducted to assess this machine. To assess a device for deflection performance it is necessary to have 5 laps with a suitable reference dataset to compare against. To this end two more laps were undertaken with the whole fleet (laps 7 and 8) and as it was late in the day by two more with a subset of machines (laps 9 and 10). All of the data collected was used in the investigation of Machine 03 however only the data from the subset of machines is shown below for the additional laps.

The between-run standard deviation for laps 6 to 10 for the machines that took part in all of the additional laps is shown in Table 8.1.

Table 8.1: Between-run standard deviation for day 3 (laps 6 to 10)

Machine number	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
2	2.6	1.2	13.9	8.7	9.3	10.2
3	1.6	1.9	6.9	5.0	9.6	5.7
10	4.0	1.8	11.5	4.8	8.6	6.2
15	1.9	3.1	9.6	8.2	4.0	7.0

As with the main testing, it can be seen from Table 8.1 that despite some variation in values, no machine was obviously more variable than the others.

The mean deflections recorded on each section together with summary statistics for laps 6 to 10 for these machines are shown in Table 8.2. The deviations from the overall mean are shown in Table 8.3.

Table 8.2: Mean deflection (µm) by section: day 3 (laps 6-10)

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	51	43	262	215	161	138	158	132
3	30	33	217	187	128	118	125	113
10	59	54	274	246	167	181	167	160
15	51	53	255	216	147	146	151	138
Mean	48	46	252	216	151	146	150	136
BESD	12.2	10.2	24.6	23.9	17.0	26.1	17.8	19.7
BESD criterion	11.1	11.1	16.4	15.4	13.8	13.6	13.7	13.4
CoV	25.5%	22.3%	9.8%	11.1%	11.3%	17.9%	11.9%	14.5%

Table 8.3: Deviation (µm) from overall mean deflection by section: day 3 (laps 6-10)

Machine number	HECP_01		HECP_02		HECP_03		Average	
	NS	OS	NS	OS	NS	OS	NS	OS
2	3.6	-3.0	9.8	-1.1	9.8	-7.7	7.7	-3.9
3	-17.4	-13.1	-35.0	-28.9	-22.4	-27.3	-24.9	-23.1
10	10.9	8.8	22.0	29.6	16.2	35.2	16.4	24.6
15	3.0	7.2	3.1	0.3	-3.6	-0.2	0.8	2.5
2x BESD criterion	22.2	22.1	32.7	30.9	27.5	27.2	27.5	26.7
3x BESD criterion	33.3	33.2	49.1	46.3	41.3	40.9	41.2	40.1

From Table 8.2 it can be seen that the BESD criterion is not met for the average of the site in either wheel path (and is not met for most wheel path and section combinations). As the other machines in this testing have performed suitably previously in the trial, this would initially suggest that Machine 3 has not met the trial criteria. However, this analysis is based on a subset of the fleet which means that it might not reflect the average of the whole fleet. Therefore, it is also necessary to combine this data with the main dataset from the trial before making a final decision.

In order to combine the data from the two datasets, the average deflection values for each wheel path and section for the reference machines was calculated for each dataset i.e. for laps 2-6 and 6-10. The ratio between these values was then applied to the data from Machine 3 (from laps 6 to 10) to provide an estimate of the likely deflections that this machine would have measured if it had operated in its current configuration during the main set of testing (i.e. laps 2-6).

The average deflections from the two datasets for the machines acting as reference and the calculated ratios are shown in Table 8.4

Table 8.4: Reference data values and estimation ratio

	HECP_01		HECP_02		HECP_03	
	NS	OS	NS	OS	NS	OS
Average laps 2 to 6	53	48	243	204	139	133
Average for laps 6 to 10	54	50	263	226	158	155
Ratio	0.98	0.95	0.92	0.90	0.88	0.86

Table 8.5 shows the mean deflections recorded on each section for the combined dataset, 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 8.6 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). In both of these tables, Machine 3 is in blue italic text to highlight that it is an predicted value.

Table 8.5: 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	46	39	233	189	133	112	137	113
3 (prediction)	*30*	*31*	*200*	*169*	*113*	*101*	*114*	*101*
5	47	40	234	183	132	117	138	113
8	49	52	228	211	130	139	136	134
9	43	50	205	193	112	126	120	123
10	63	52	260	227	155	158	159	146
12	41	44	223	209	126	136	130	130
14	59	48	253	204	158	137	157	129
15	50	52	237	197	130	128	139	126
16	55	48	248	206	148	132	150	129
Mean	48	46	232	199	134	129	138	124
BESD	9.4	7.0	19.3	16.2	15.7	15.8	14.5	12.6
BESD criterion	11.1	11.1	15.8	15.0	13.3	13.2	13.4	13.1
CoV	19.5%	15.4%	8.3%	8.2%	11.8%	12.3%	10.5%	10.1%

Table 8.6: 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	-2.2	-6.6	0.7	-10.2	-0.4	-16.8	-0.6	-11.2
3 (prediction)	*-18.4*	*-14.6*	*-32.1*	*-29.4*	*-20.5*	*-27.2*	*-23.7*	*-23.7*
5	-1.2	-5.3	2.0	-16.2	-1.5	-11.5	-0.2	-11.0
8	1.0	6.4	-3.7	11.8	-3.3	10.1	-2.0	9.4
9	-4.9	4.8	-27.2	-5.3	-22.1	-2.3	-18.0	-0.9
10	14.4	6.3	27.5	28.1	21.1	29.3	21.0	21.2
12	-7.5	-1.8	-9.3	10.2	-7.9	7.5	-8.3	5.3
14	11.0	2.0	21.3	4.8	24.3	8.2	18.9	5.0
15	1.5	6.5	4.5	-1.4	-3.5	-0.5	0.8	1.5
16	6.3	2.4	16.2	7.6	13.9	3.2	12.1	4.4
2x BESD criterion	22.2	22.1	31.7	30.0	26.6	26.4	26.9	26.2
3x BESD criterion	33.4	33.2	47.5	45.0	39.9	39.6	40.3	39.2

It can be seen from Table 8.5 that the BESD criterion is not met for the average of the site for the Nearside wheel path. It can also be seen from

Table 8.6 that Machine 03 is the only machine to be more than 2 times the BESD criterion away from the fleet mean on the Nearside measurements (section 2).

Therefore, following this additional testing it has been identified that Machine 03 has **not** met the criteria for deflection measurements.

It is noted that both Machines 03 and 10 are more than 2 times the BESD criterion away from the fleet mean for the Offside measurements on section 3. However, the BESD criterion is met for the average of the site for the Offside wheel path and as such this is not a concern. It is worth noting that if any machine was more than 3 times the BESD criterion away from the fleet mean then it would be identified as not suitable, regardless of the resulting BESD value.

9 Conclusions

The 2021 National Deflectograph accreditation trials were held on the Horiba-MIRA proving grounds by TRL on behalf of Highways England in the week beginning the 22nd February 2021. 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

All ten machines were within the wheel and axle limits as defined in the Accreditation and QA specification (TRL, 2020).

(II) Deflection measurement

Nine of the ten machines that participated in the trial met the criteria for deflection measurement.

(III) Distance measurement

All ten machines that participated in the 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

Two of the ten operators achieved a high performance with regards to the measurement of temperature at depth. The remaining eight achieved a medium performance.

(V) Temperature measurement – surface temperature

Surface temperature data from four machines was supplied at this trial. All four machines achieved a medium performance.

(VI) Temperature measurement – air temperature

Air temperature data from four machines was supplied at this trial. Three machines achieved a high performance, and one a medium.

A summary of the machines that attended the 2021 accreditation trial and the criteria that they met/performance achieved can be found in Appendix A.

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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	Fail	Pass	Medium	Not assessed	Not assessed
5	WDM Ltd	D962 JRU	Pass	Pass	High	Not assessed	Not assessed
8	WDM Ltd	BYW 80V	Pass	Pass	Medium	Medium	Medium
9	WDM Ltd	VGV 182X	Pass	Pass	Medium	Medium	High
10	WDM Ltd	F569 JBB	Pass	Pass	Medium	Medium	High
12	WDM Ltd	EOU 230W	Pass	Pass	Medium	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	Medium	Not assessed	Not assessed
16	WDM Ltd	B880 XOU	Pass	Pass	Medium	Medium	High

Appendix B Layout of test sections at Horiba-MIRA

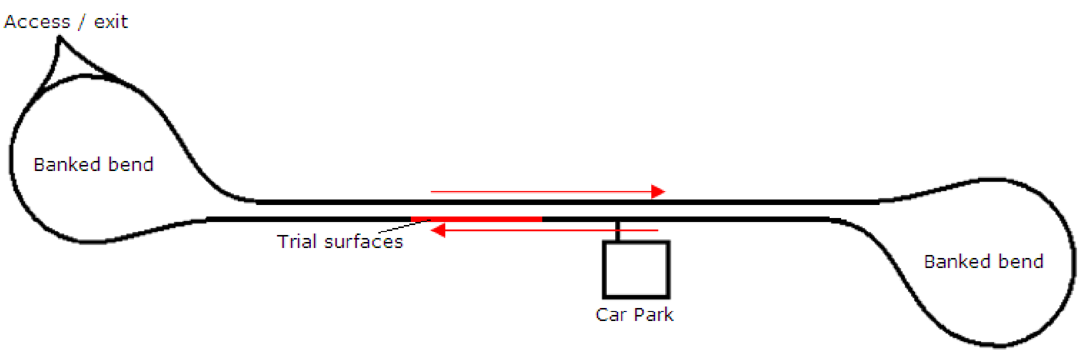

Figure B.1: Test route on the Horiba-MIRA twin straights

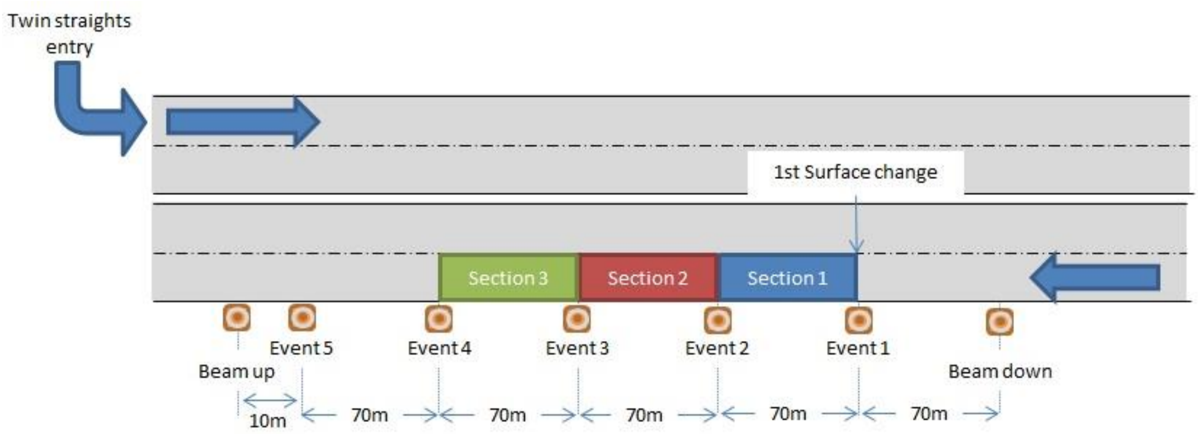

Figure B.2: Location of marker cones and test sections on Horiba-MIRA twin straights

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

Appendix D Criteria for acceptability

The accreditation trial criteria are specified in "Accreditation and Quality Assurance of Deflectograph Survey Devices" (TRL, 2020). This document is a live document (i.e. is subject to change) and the most recent (June 2020) version of the document was used for the trial. The relevant section of the document is reproduced verbatim below in Section D.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.

D.1 Trial criteria from the Accreditation and QA document

E3. Equipment inspection

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

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

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

Table 1 – Criteria for wheel weights

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

[1] It has been the experience in the Accreditation Trials that Equipment falling within 15% above the 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 expanded front axle range would continue to be regarded as acceptable provided that they performed satisfactorily in the dynamic tests.

E3.4 A simple assessment of the temperature probe used for the direct measurement method should be carried out to make sure that it is producing consistent results.

E3.5 Equipment which has infra-red temperature sensors for determining surface temperature fitted should be checked to confirm that the emissivity settings have been set to the manufacturer's recommended setting for asphalt.

E.4 Running Trials

E4.1 Overview

E4.1.1 As detailed in in Appendix B, trials shall 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 shall 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 shall be collected at a test speed of 2.4±0.1 km/h. Equipment shall be checked by measuring the time taken to travel a known length. If the Equipment is found to be surveying outside the test speed range, the survey operator shall be asked to adjust their speed accordingly. Laps for Equipment where the survey speed requirements are not met shall be excluded from the assessment.
- Instances where the rate of change in temperature measured at 40mm is greater than 2.5˚C per hour measured over a period of 15 minutes shall be investigated. If the variation of deflection data is seen to be to large then the lap should be disregarded and an additional lap undertaken.

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

E4.2.4 The Auditor shall 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 shall 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 shall be used to assess the repeatability of each individual Equipment.

E4.2.5 The BRSD shall 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 shall 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 shall 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 shall be further examined to identify outlying Equipment. This shall include examining the Fleet BESD and data from individual Equipment. Outlying Equipment shall 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 shall fail Accreditation. Any Equipment that is between two and three times the BESD criterion from the Fleet mean shall 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 shall 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 shall be assessed for both wheel paths separately. To achieve Accreditation the Equipment shall meet the requirements for both the NS wheel path and the OS wheel path.

E4.2.11 In addition to the above assessments the Auditor should review the profiles of the Survey Data over the site for each Equipment and investigate any anomalies. Based on the results of the investigation the Auditor may withhold Accreditation for Equipment and/or issue an Improvement Notice as detailed in Section H.

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 – direct measurement method

E5.2.1 If undertaking this test, the Contractor should 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. These probes are required to provide results to a resolution equal to or better than 0.1˚C. Therefore if the probe does not then it shall be identified as “Not Suitable” regardless of the performance seen for the measurements (with a note identifying the reason for the performance given). The criteria for the assessment of the direct measurement method are given in Table 4.

Table 4– Criteria for direct measurement method

Performance level	Measurement of temperature
High	≥80% of the measurements are within 1.0ºC of the reference
Medium	≥50% of the measurements are within 1.0ºC of the reference
Low	≥15% of the measurements are within 1.0ºC of the reference
Not Suitable	Otherwise

E5.3 Temperature measurement –Contactless measurement

E5.3.1 If undertaking this test, the Contractor shall be required to make measurements of the air and surface temperature (at locations specified by the Auditor) so that at least eight pairs of measurements are taken during the course of the test laps. These sensors are required to provide results to a resolution equal to or better than 0.1˚C. Therefore if the sensor does not then it shall be identified as “Not Suitable” regardless of the performance seen for the measurements (with a note identifying the reason for the performance given). The criteria for the assessment of surface temperature measurement are given in Table 5 and the assessment of air temperature measurement are given in Table 6.

Table 5– Criteria for surface temperature measurement

Performance level	Measurement of temperature
High	≥80% of the measurements are within 1.0ºC of the reference
Medium	≥50% of the measurements are within 1.0ºC of the reference
Low	≥15% of the measurements are within 1.0ºC of the reference
Not Suitable	Otherwise

Table 6– Criteria for air temperature measurement

Performance level	Measurement of temperature
High	≥80% of the measurements are within 1.0ºC of the reference
Medium	≥50% of the measurements are within 1.0ºC of the reference
Low	≥15% of the measurements are within 1.0ºC of the reference
Not Suitable	Otherwise

E5.3.2 In addition to providing the air and surface temperatures the Survey Contractor shall provide the predicted temperature at 40mm depth using this data. The Auditor may allow Survey Contractors to provide these predicted temperatures after the trial to allow for processing time. The Auditor shall confirm on the Accreditation Certificate whether the calculations have been accurately calculated.

Highways England 2021 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 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 2021 accreditation trial run by TRL and held on the HORIBA-MIRA proving ground between 23rd and 25th of February 2021.

Other titles from this subject area

PPR977	Highways England 2020 National Deflectograph Accreditation Trial. S Brittain. 2022
PPR1018	Highways England 2019 National Deflectograph Accreditation Trial. S Brittain. 2022
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PPR 941	Highways Agency 2017 National Deflectograph Accreditation Trial. S Brittain. 2020

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