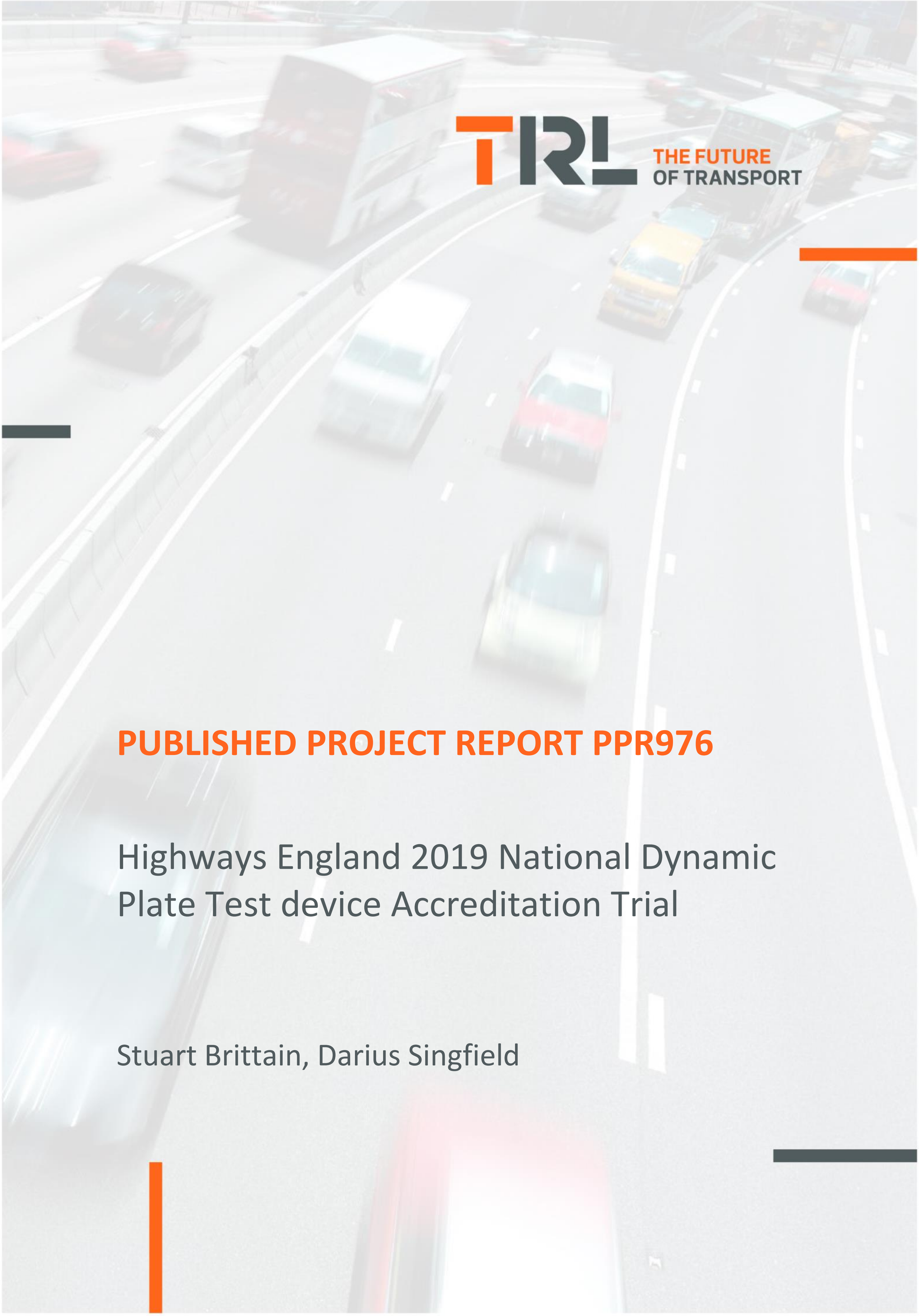

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Highways England 2019 National Dynamic Plate Test device Accreditation Trial

Stuart Brittain, Darius Singfield

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Executive Summary

The 2019 UK Dynamic Plate Test (DPT) device accreditation trial was held on the Twin Straights on the Horiba-MIRA proving ground, on the 24th and 25th September 2019. This was the twenty-first mandatory DPT accreditation trial to be held in the UK with the objective being to assess the performance of all DPT devices likely to be operating on the Highways England Strategic Road Network (SRN). DPT devices include Falling Weight Deflectometers (FWDs), Heavy Weight Deflectometers (HWDs) and Super Heavy Weight Deflectometers (SHWDs).

The performance of individual machines was assessed by examining and reviewing the results from the machines operating on specified test sections. Only machines that can demonstrate satisfactory performance in the accreditation trial may subsequently be approved for use on the SRN.

A total of twenty-four machines took part in the trial, consisting of:

- Thirteen trailer-mounted Dynatest FWDs;
- Seven trailer-mounted Dynatest HWDs ;
- Three trailer-mounted Grontmij FWDs; and
- One trailer-mounted Rincent HWD.

The trial followed a similar format to that which was used successfully in previous mandatory trials carried out since 1999. The trial takes place over 3 days with machine inspections, distance calibration, and initial testing held on the first day. The main testing is held on the second day, and the third day is used for contingency in case of bad weather or other unforeseen circumstances (it was not used in this trial). The tests undertaken this time comprised the following:

- Repeatability of deflection measurement (a mandatory test);
- Reproducibility of deflection measurement (a mandatory test);
- Accuracy of measurement of elapsed distance against an independent reference (a mandatory test);
- Accuracy of temperature measurement devices (a non-mandatory test);
- Accuracy of measurement of pavement temperature (at 100mm and surface temperature) against an independent reference (a non-mandatory test); and
- Accuracy of 3-dimensional positional data where fitted (a non-mandatory test).

The deflection tests and associated acceptance criteria are based on, but not identical to, those published by the CROW standards organisation in the Netherlands. In August 2011 CROW issued an updated version of their recommendations (CROW, 2011) to include the repeatability test.

Based on the results from this trial and previous trials, it is recommended that the temperature at depth criteria is transformed into a mandatory criterion for future trials.

At a future date the surface temperature criteria should also transition to a mandatory test. However, it is worth noting that surface temperature measurement equipment is only fitted to some of the devices, so it would only be mandatory for those wishing to supply surface temperature measurements. Following anticipated changes to the replacement to HD29, at future trials there may be some devices being assessed for only the measurement of temperature at depth, and some devices for only the surface temperature measurement (and some for both).

At the completion of the trial it was identified that:

- Twenty-three of the twenty-four machines met the mandatory criteria of the trial.
- 3-dimensional position data was supplied by thirteen of the test machines. This data was provided in lat/long/height format. After conversion of the data by TRL into the OSGR format, six machines achieved a high rating, four a medium, one a low and two a “not suitable” rating. The contractors’ coordinate transformation to OSGR format was not assessed. It is worth noting that other types of survey devices that operate on the Highways England network provide their data in OSGR format and as such consideration should be given to imposing the requirement of providing the data in OSGR format.
- All twenty-four machines provided a full set of temperature measurements at depth. Thirteen machines achieved a high rating, six a medium rating, four a low rating and one was identified as not suitable.
- Eleven machines provided surface temperature measurements. Three machines achieved a high rating, two a medium rating, five a low rating and one was identified as not suitable.
- Thirteen machines provided air temperature measurements. Although air temperature measurements from the DPTs do not form part of the updated test method, it seemed prudent to review the data supplied. Applying the surface temperature criteria to the measurements, four machines achieved a high performance level, six were medium, two low and one was identified as not suitable.

1 Introduction

Current advice on the use of Dynamic Plate Test devices, provided in HD29/08 (where they are referred to as FWDs) of the Design Manual for Roads and Bridges (DMRB 7.3.2), requires that all of these devices be tested and approved at an annual FWD accreditation trial before being accredited for operating on the Highways England Strategic Road Network (SRN). A similar requirement has been in place for side force skid resistance devices and Deflectographs for many years, and forms part of a system to ensure that consistent, high quality data is obtained from condition surveys of the SRN in England. In addition, Defence Estates' Design and Maintenance Guide 27, "A Guide to Airfield Pavement Design and Evaluation" requires that FWDs be approved at an annual accreditation trial before they may be permitted to survey on MoD airfields.

As satisfactory performance at an accreditation trial is required for subsequent accreditation for use on the SRN, the trial is henceforward referred to as an accreditation trial. In addition, as the trial covers FWD, HWD and SHWD, the trial is also referred to as a DPT trial rather than an FWD trial.

The objectives of the 2019 DPT Accreditation trial were:

- To ensure that all measuring systems are well maintained and in good mechanical order (through inspection of each machine at the trial).
- To ensure consistent performance of individual machines and the reproducibility of all machines, including any supporting measurements (i.e. temperature and location).
- To monitor and seek improvements in performance over the longer term.

The twenty-first mandatory UK DPT accreditation trial was held on the 24th and 25th September 2019 on behalf of Highways England. The trial followed the basic format that was used successfully in the previous mandatory trials carried out since 1999. The 2019 trial included the following mandatory checks:

- Reproducibility;
- Repeatability; and
- Distance measurement.

And the following non-mandatory checks

- Temperature measurement devices/probes calibration check;
- Temperature measurement at 100mm, air and surface; and
- OSGR data (obtained from 3-dimensional positional systems).

These tests and associated acceptance criteria are broadly based on those published by the CROW Standards organisation in the Netherlands. In August 2011 CROW issued an updated version of their recommendations (CROW, 2011) which has been used to guide the design of the tests incorporated in this trial.

From 1999 to April 2010 the trials were conducted on the Small Roads System at TRL. The trial was then conducted at the Horiba-MIRA Proving grounds in Warwickshire in November

2010 and October 2011. Due to programming issues the trial returned to the Small Roads System at TRL for the November 2012 trial. The 2013 trial and subsequent trials have all been held on the proving grounds at Horiba-MIRA. This report describes the conduct and findings of the September 2019 accreditation trial and presents the details of the machines that took part in the trial.

2 Trial details

2.1 Participants

Twenty-four machines (all trailer-mounted) took part in the 2019 Highways England DPT accreditation trial, comprising sixteen FWDs and nine HWDs. A total of fifteen owning organisations took part, with the machines in attendance shown in Table 2.1.

Table 2.1: DPT devices attending the trial

Company	Devices brought to trial
AECOM	2×Dynatest 8002 FWD, 2×Dynatest 8082 HWD
Atlas Geophysical Limited	Grontmij Primax 2100 FWD
Balfour Beatty	Dynatest 8002 FWD
CET	Dynatest 8002 FWD
Dynatest	Dynatest 8012 FWD, Dynatest 8082 HWD, Dynatest 8002 FWD
James Fisher Testing Services Ltd.	Grontmij Primax 2500 HWD, Dynatest 8012 FWD
Milestone Pavement Technologies	Grontmij Primax 1500 FWD
PMS Ltd. (Eire)	2 × Dynatest 8002 FWD and 1 x Dynatest 8082 HWD
PTS Ltd.	1 × Dynatest 8002 FWD and 3 x Dynatest 8082 HWD
Pulse Surveying Ltd.	2 x Dynatest 8002 FWD
SOCOTEC	RINCENT HeavyDyn
TRL	Dynatest 8002 FWD

More details of the attending machines are provided in Appendix A and example photographs are given in Appendix B.

In this report the individual machines are referred to by the running numbers assigned to them for the trial. For ease of comparison, machines usually retain the same running number year-on-year.

2.2 Preparation of vehicles

All operators were provided with detailed instructions for the trial and asked to prepare their machines for testing under standard conditions prior to their arrival at the trial, as follows:

- Positions of deflection sensors: 0, 300, 600, 900, 1200, 1500 and 2100 mm. Note: this is the “flexible and flexible-composite” set-up described in HD29/08 and is different from the positions used for trials before 2013.
- Standard loading plate, diameter 300mm.
- Data storage in standard metric output (“.F20” or “.F25” format).

For the repeatability testing the following were also specified:

- Load 50kN (fixed height, seek may not be used).
- Configured for 12 drops at each test station.

For the reproducibility testing the following were also specified:

- Load 50kN (fixed height or seek).
- Configured for 5 drops at each test station.

Operators were also advised to have the peak smoothing function, if available, activated.

2.3 Inspection of vehicles

Operators were asked to provide details of the latest manufacturer’s calibration and their own dynamic calibrations and stack/tower consistency checks prior to the start of the trial. The machines were subsequently checked by a TRL inspector before testing began to ensure that the machines were set up correctly and configured as required for the trial. The findings are summarised in Appendix A.

2.4 Location of trial

Four test sections were used for the trial; each with different constructions and associated deflection levels, and located on the Twin Straights on the Horiba-MIRA proving ground. Each section contained three test stations (12 stations in total) which were clearly marked out using road paint (see Figure 2.1 below) and swept clear of debris prior to the trial. An additional station (number 13) is located on a concrete section and this station (along with 2, 5 and 8) is used in the repeatability testing. Two additional test lengths were set up; one to allow operators to undertake distance calibrations and one for the odometer test. Nominal construction details for the four deflection test sections can be found in Appendix C. Crews were instructed that the loading plate should be placed completely within the marked box for testing.

Figure 2.1: Test station marked by a painted box

2.5 Temperature monitoring

Temperatures were measured throughout the trial using two sets of temperature sensors and data loggers. Each set contained thermocouples to measure the 40mm and 100mm pavement temperatures and also the air and pavement surface temperatures. One set was located near station 2 and the other near station 11. The loggers connected to the sensors were set to record the temperature measurement once every minute.

2.6 Test programme

Details about the trial, including the test programme and instructions, were provided to all participants in advance of the trial. An outline of the trial programme is presented below.

2.6.1 Day 1 – inspection, familiarisation and repeatability testing

Day 1 is used to conduct machine inspections, a familiarisation lap and repeatability tests. The familiarisation lap is designed to give new operators the chance to familiarise themselves with the course, and to identify any obvious problems with machines that would otherwise delay progress during the trial.

TRL staff members were available during testing to assist crews with positioning at test stations.

The familiarisation lap follows the same format as used for day 2 (reproducibility testing) with five replicate drops at each of the standard twelve test stations. The peak values of load and deflection are recorded as well as time histories. For this testing operators are recommended to activate the load “Seek” setting (if available).

Four stations (2, 5, 8 and 13) have been selected for the repeatability testing. For this testing two laps of twelve replicate drops at each station are required, with peak values of load and deflection recorded as well as time histories. For the repeatability testing the load “Seek” setting is switched off.

The crews are also asked to perform a distance calibration using a marked-out length of 400m.

The operators’ hand-held temperature probes (including probes attached to DPT devices) are compared using a stabilised environment to provide a simple check on the calibration of these devices.

2.6.2 Day 2 – reproducibility testing

Reproducibility tests are conducted on day 2. As with day 1, TRL staff members are available during testing to assist crews with positioning at test stations.

Five replicate drops are made at the twelve test stations, with peak values of load and deflection recorded as well as time histories. Each complete set of 12 test stations is referred to as a lap.

The first lap is treated as a warm-up lap, and is then followed by at least two test laps. After completing each lap, the all of the collected data is handed over to TRL staff before beginning the next lap, and any anomalies reported by operators are recorded. Real-time data processing enables summary results of each lap to be available to the TRL inspectors soon after each lap is completed.

During each lap the crews were asked to make temperature measurements using pre-drilled holes (the same ones used for the temperature loggers to measure the 100mm depth). In addition, on returning to the start of the test site the operators were asked to measure a predefined length to provide an assessment of the odometers fitted to the equipment.

2.6.3 Day 3 – contingency day

Day 3 is reserved for contingency for bad weather or other unforeseen circumstances. This day was not used during the 2019 trial.

3 Assessment criteria

The accreditation trial criteria are specified in "Accreditation and Quality Assurance of Dynamic Plate Test Survey Devices" (TRL, 2016). The accreditation document is a live document (i.e. is subject to change) and the July 2016 version of the document was used for the trial. The relevant sections of the document are reproduced verbatim below in blue text (section 3.1 and 3.2). Note that the appendices referred to in section 3.1 and 3.2 are not included in this report.

Note that 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 load measurement system, 3-dimensional position system, distance 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.

3.1 Mandatory Trial criteria from the Accreditation and QA document

E4.2 Repeatability testing – Mandatory Requirement

E4.2.1 Repeatability testing will be conducted on a series of test stations identified by the Auditor. The requirements for these test stations are given in Appendix C.

E4.2.2 Repeatability testing will use a test procedure typical of general usage on the network. The test procedure will include a minimum of two seating drops and ten measurement drops at each test station. The specific details of the test procedure for Repeatability testing (including nominal peak load and number of drops) will be communicated by the Auditor prior to the trial.

E4.2.3 It is noted that some Equipment have drop height variation functionality which varies the drop height based on the load measured on the previous drops (sometime referred to as "seek" mode). This functionality may not be used for the repeatability testing.

E4.2.4 The following must be achieved with regards to the load applied on each station:

- The mean load applied shall be within 10% of the target load.
- The standard deviation of the load recorded shall be less than, or equal to two percent of the mean of the recorded values.

E4.2.5 In the event that these load requirements are not achieved the data will be disregarded and additional tests will be undertaken. If the Equipment does not meet the load requirements given above in subsequent tests then it is deemed to be unable to undertake the assessment and have failed the Repeatability criteria.

E4.2.6 The valid Repeatability data will be collected and the Equipment will pass the Repeatability test if it meets the criteria given in Table 1. A worked example of the analysis process is given in App D.1.

Table 1 – Deflection Repeatability Criteria

Parameter	Acceptability Limit
Standard deviation of load corrected deflections	95% of the data less than or equal to 2µm or the sum of 1µm and 0.75% of the mean of the recorded normalised values (whichever is greater)

E4.3 Reproducibility testing – Mandatory Requirement

E4.3.1 Reproducibility testing will be based on at least two test sets conducted on a series of test stations identified by the Auditor. The requirements for these test sets and test stations are given in Appendix C.

E4.3.2 To be classified as a valid Reproducibility test the 100mm pavement temperature must not change by more than ±3°C between tests conducted by the different Equipment on the same test station in each test set. If the temperature varies by more than this then this is likely to introduce additional variation to the Survey Data of the Equipment and should be disregarded. Additional test sets should then be undertaken in order to obtain the required amount of Survey Data within the required temperature range.

E4.3.3 Reproducibility testing will use a test procedure typical of general usage on the network. The test procedure will include a minimum of one seating drop and four measurement drops at each test station. The specific details of the test procedure (including nominal peak load and number of drops) will be communicated by the Auditor prior to the trial.

E4.3.4 The Field Calibration Factor (FCF) and the Standard Deviation of the Deviation Ratio (SDDR) are used as the basis for the assessment of Reproducibility.

E4.3.5 For each deflection sensor the reference deflection divided by the Equipment's mean deflection, averaged over all test stations, is defined as the FCF for that sensor. The overall FCF for each Equipment is calculated by averaging the FCF values for the individual sensors. The FCF therefore indicates, on average, how well the deflections recorded by each Equipment relate to the reference deflection basins.

E4.3.6 The difference between the deflection measured by each sensor at each test point and that of the reference deflection basin, expressed as a fraction of the reference deflection is defined as the Deviation Ratio. For each Equipment, the SDDR is calculated over all test stations and gives an indication of the consistency with which the Equipment tends to over-read or under-read over the set of test stations.

E4.3.7 The FCF and SDDR statistics will be calculated for each test set. The Equipment will pass the Reproducibility test if the criteria in Table 2 are met for each test set. A worked example of the analysis process is given in App D.2.

Table 2 - Deflection Reproducibility Criteria

Parameter		Maximum	Minimum
FCF	Mean for all sensors	1.05	0.95
	Individual sensor value	1.10	0.90
SDDR	Mean for all sensors	0.05	N/A
	Individual sensor value	0.07	N/A

E4.3.8 Occasionally, Equipment will produce isolated anomalous sensor readings which may result in FCF or SDDR values falling outside the acceptable limits. To compensate for this the accreditation procedure allows for the measurement from a single sensor from one test station to be removed from the analysis of each lap of the test site if required.

E4.4 Location Referencing Testing (Distance) – Mandatory Requirement

E4.4.1 Accreditation of an Equipment's ability to measure distance is carried out by comparing its measurements of a test length with the Reference Data. The test is carried out at least four times. All of the test measurements must be within the criteria given in Table 3.

Table 3 - Acceptance Criteria for Location Reference Measurement

Parameter	Acceptability Limit
Elapsed chainage versus Reference Data	± 2m or 1% (whichever is greater)

3.2 Additional test criteria from the Accreditation and QA document

E5.2 Location reference – OSGR coordinates

E5.2.1 For Equipment undertaking this test, the difference in position (as the horizontal error) between the reported OSGR coordinates from each test station and the reference OSGR coordinates will be calculated. A minimum of 18 stations will be used to undertake this test (either 18 different test stations or a lower number of test stations using multiple laps). The criteria for the assessment of OSGR coordinates are given in Table 4.

Table 4 - Acceptance Criteria for OSGR data

Performance	Criteria
High	75% of the data is within 2m of the Reference Data
Medium	75% of the data is within 5m of the Reference Data
Low	75% of the data is within 10m of the Reference Data
Not suitable	Otherwise

E5.3 Temperature measurement – temperature sensor for measurement at depth (within the pavement)

E5.3.1 If undertaking this test, the Contractor will be required to collect at least eight measurements in the pre-drilled holes (100mm depth) during the course of the test laps. The criteria for the assessment of temperature measurement at depth are given in Table 5.

Table 5 - Acceptance Criteria for temperature measurement at depth

Performance	Criteria
High	80% of the data is within 1˚C of the Reference Data
Medium	60% of the data is within 1˚C of the Reference Data
Low	25% of the data is within 1˚C of the Reference Data
Not suitable	Otherwise

E5.3.2 The Re-accreditation trial may also incorporate a check on the calibration of the temperature Systems via measurement of a static sample of known temperature (e.g. ice).

E5.4 Temperature measurement – temperature sensor for surface measurement

E5.4.1 If undertaking this test the Contractor will be required to collect at least eight measurements of the pavement surface at defined points during the course of the test laps. The criteria for the assessment of temperature measurement of the pavement surface are given in Table 6.

Table 6 - Acceptance Criteria for temperature measurement of pavement surface

Performance	Criteria
High	80% of the data is within 1˚C of the Reference Data
Medium	60% of the data is within 1˚C of the Reference Data
Low	25% of the data is within 1˚C of the Reference Data
Not suitable	Otherwise

4 Results – day 1

4.1 Machine set-up and configuration

The machine checks on the first day of the trial ran efficiently due largely to the vehicle inspection check sheets being sent to participants and completed prior to the trial, ensuring that most of the machines arrived correctly set up and configured with only minor checks required by TRL staff.

Appendix A itemises the configuration of the various machines, while Table 4.1 summarises the findings of the inspection with regards to certain key parameters that either affect operation or are requested in the trial documentation.

Table 4.1: Summary of DPT configurations on arrival

Checklist item	Number compliant (out of 24)
Completed Check list returned to TRL before trial	16
Date of last tower calibration	23
Date of last dynamic calibration	21
Date of last manufacturer’s calibration	23
All seven geophones in correct positions	16

Since the 2007 accreditation trial, it has been agreed with the DPT operators that routine dynamic and tower calibration records be made available for viewing at the accreditation trial. The dates supplied by the contractors for their latest calibrations (regardless of whether evidence of the calibration was supplied) is shown in Appendix A.

4.2 Day 1 familiarisation lap

The data from the familiarisation lap is shown in Figure 4.1 and Figure 4.2 below. In these figures the circle and square show the mean FCF and SDDR respectively for the machine on the lap. The error bars show the range of the FCF and SDDR values for each geophone. In the full assessment the machines would be deemed suitable if the mean FCFs are within the mean limit (i.e. between 0.95 and 1.05), the individual FCFs within the individual limit (i.e. between 0.90 and 1.10), and the SDDR mean and individual values are below their corresponding limits (0.05 and 0.07 respectively).

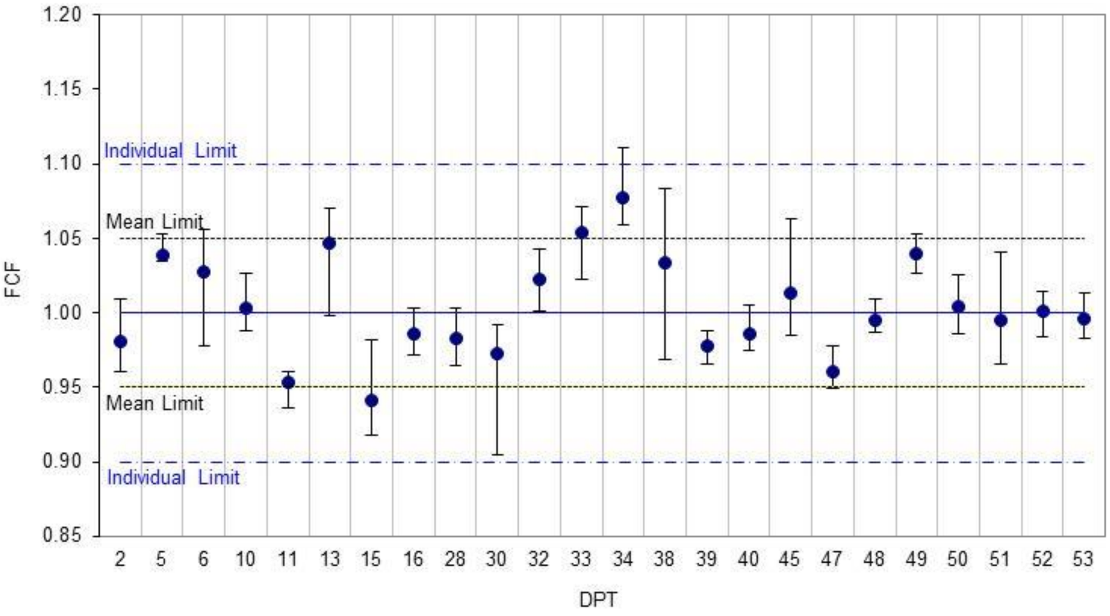

Figure 4.1: FCF (familiarisation lap – full dataset)

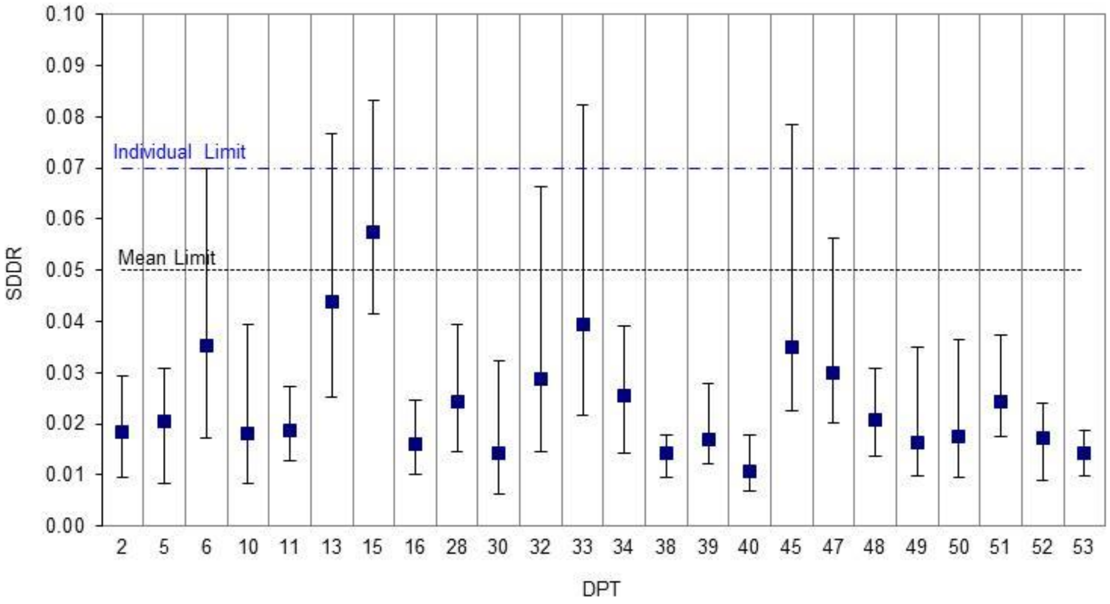

Figure 4.2: SDDR (familiarisation lap – full dataset)

On examination of the familiarisation lap data it was found that Machines 15, 33 and 34 exceeded the limits for mean FCF, in addition Machine 34 exceeded the limits for individual geophones.

Machine 15 exceeded the limits for the mean SDDR, and Machines 13, 15, 33 and 45 exceeded the limits for the individual SDDR limit.

However, due to the chances of isolated anomalous sensor readings, the accreditation rules permit the measurement from a single sensor from one test station to be removed from the analysis lap. After removing one point and reanalysing, it was found that machines 15, 33 and 34 still did not meet all of the criteria. The operators of these machines were notified and, after investigating their machines, undertook an additional lap. The data from the familiarisation and additional lap combined is shown in Figure 4.3 and Figure 4.4. Note this includes removal of a single sensor point from one test station, where appropriate.

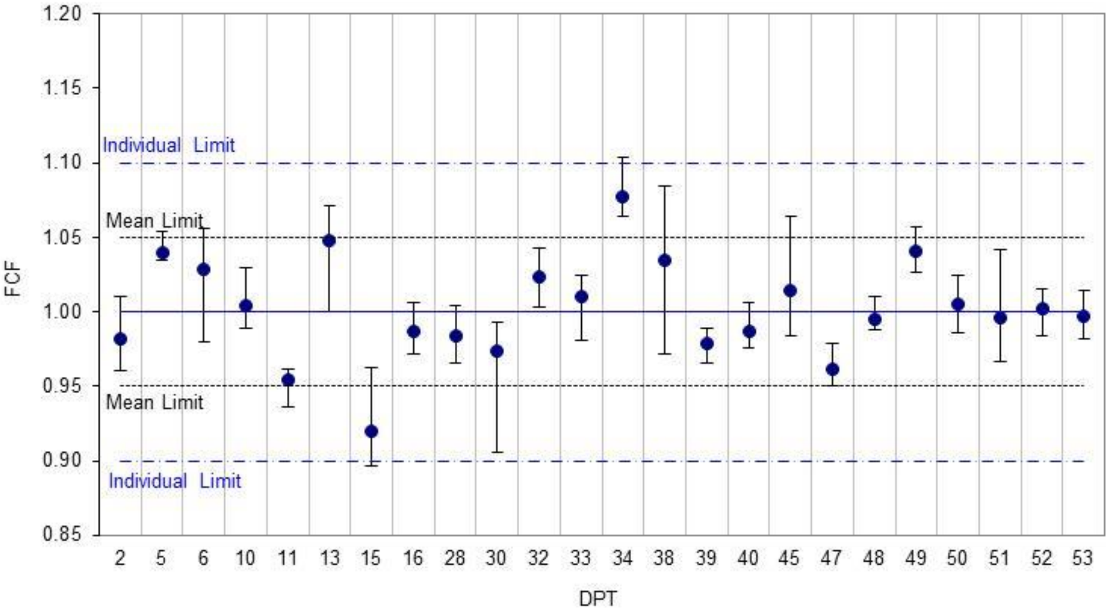

Figure 4.3: FCF (familiarisation lap & replacement lap [Machines 15, 33 and 34] – single data point removed

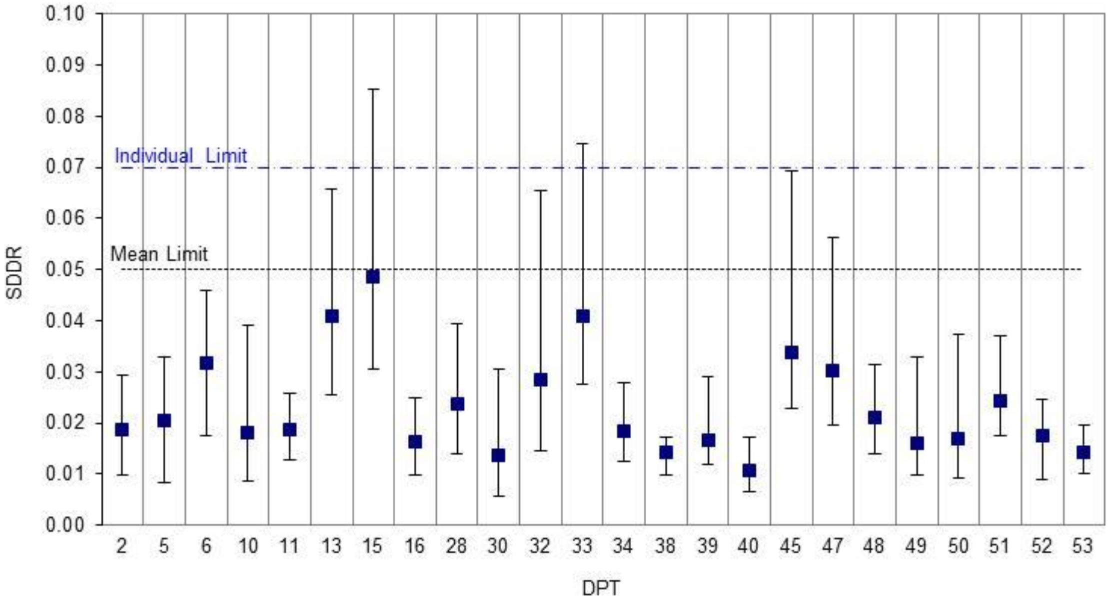

Figure 4.4: SDDR (familiarisation lap & replacement lap [Machines 15, 33 and 34] – single data point removed

Using this combined analysis, Machine 33 met the limits for mean FCF, however Machines 15 and 34 still exceeded them and failed to meet the individual FCF limits. All machines fell within the mean SDDR limits, however machines 15 and 33 still exceeded the individual SDDR limits.

Therefore based on the reproducibility testing done on day 1 (and after removal of a data point) the following machines 15, 33 and 34 were identified as having a potential issue. The operators of these machines were notified of these issues so that they could investigate their machines before the testing on day two.

4.3 Repeatability tests

Repeatability tests were also conducted on day 1 using stations 2, 5, 8 and 13 and the results were assessed using the test criteria in section 3.1. Any machines that underwent alterations during the trial (see section 5.2 for more details) were required to repeat the repeatability tests after these changes. Machines 11, 28 and 53 did not initially meet the load criteria for a valid test and Machine 50 did not meet the repeatability criteria. Following some alterations to the settings these four devices repeated the testing and provided suitable test laps. Table 4.2 shows the summary of the final results for the repeatability assessment for all machines.

Table 4.2: Repeatability assessment

ID	Count of failure to meet SD of normalised deflections criteria							Percentage met criteria	Status
	D1	D2	D3	D4	D5	D6	D7		
2	0	0	0	0	1	0	0	98.2%	Pass
5	0	0	0	0	0	0	0	100.0%	Pass
6	0	0	0	0	0	0	0	100.0%	Pass
10	0	0	0	0	0	1	0	98.2%	Pass
11	0	0	0	0	0	0	0	100.0%	Pass
13	0	0	0	0	0	0	0	100.0%	Pass
15	0	0	0	0	0	0	1	98.2%	Pass
16	0	0	0	0	0	0	0	100.0%	Pass
28	0	0	0	0	0	0	0	100.0%	Pass
30	0	0	0	0	0	0	0	100.0%	Pass
32	0	0	0	0	0	0	0	100.0%	Pass
33	0	0	0	0	0	0	0	100.0%	Pass
34	0	0	0	0	0	0	0	100.0%	Pass
38	0	0	0	0	0	0	0	100.0%	Pass
39	0	0	0	0	0	0	0	100.0%	Pass
40	0	0	0	0	0	0	0	100.0%	Pass
45	0	0	0	0	0	0	0	100.0%	Pass
47	0	0	0	0	0	0	0	100.0%	Pass
48	0	0	0	0	0	0	0	100.0%	Pass
49	0	0	0	0	0	0	0	100.0%	Pass
50	2	0	0	0	0	0	0	96.4%	Pass
51	0	0	0	0	0	0	0	100.0%	Pass
52	0	0	0	0	0	0	0	100.0%	Pass
53	0	0	0	0	0	0	0	100.0%	Pass

All machines achieved the required load criteria for a valid test. All Machines met the Repeatability criteria.

The full details of each repeatability test (including load applied) can be found in Appendix D.

4.4 Temperature Probes

During the inspection day the operators' hand-held temperature probes were compared to the data-loggers using a stabilised environment (a container of water). From this testing it was found that the probes were broadly consistent, with one probe providing slightly different results. The owner of this probe was notified.

5 Results – day 2

5.1 Temperature variation

The maximum permitted change in the 100mm depth pavement temperature during a test lap is 3°C. The aim of this limit is to minimise changes in deflections due to temperature changes within the pavement construction in each test lap.

On day 2, pavement temperatures were recorded at 40 and 100mm depths near stations 2 and 11. The 100mm temperatures steadily increased over the day as shown in Figure 5.1. The air and surface temperatures were also collected at stations 2 and 11 and the data is shown in Figure 5.2.

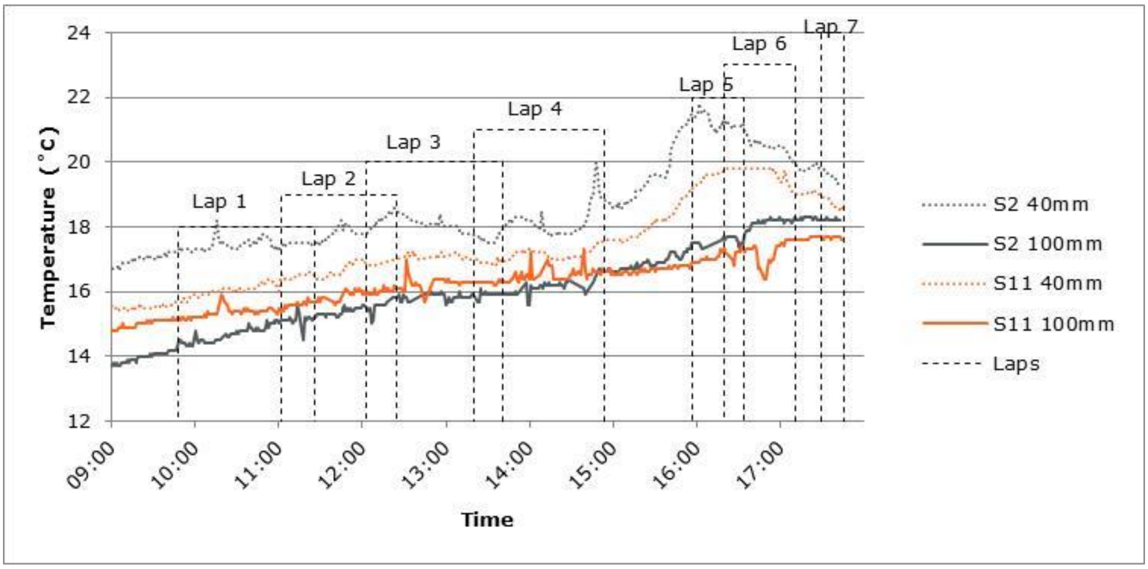

Figure 5.1: Pavement temperatures during main trial day (Day 2)

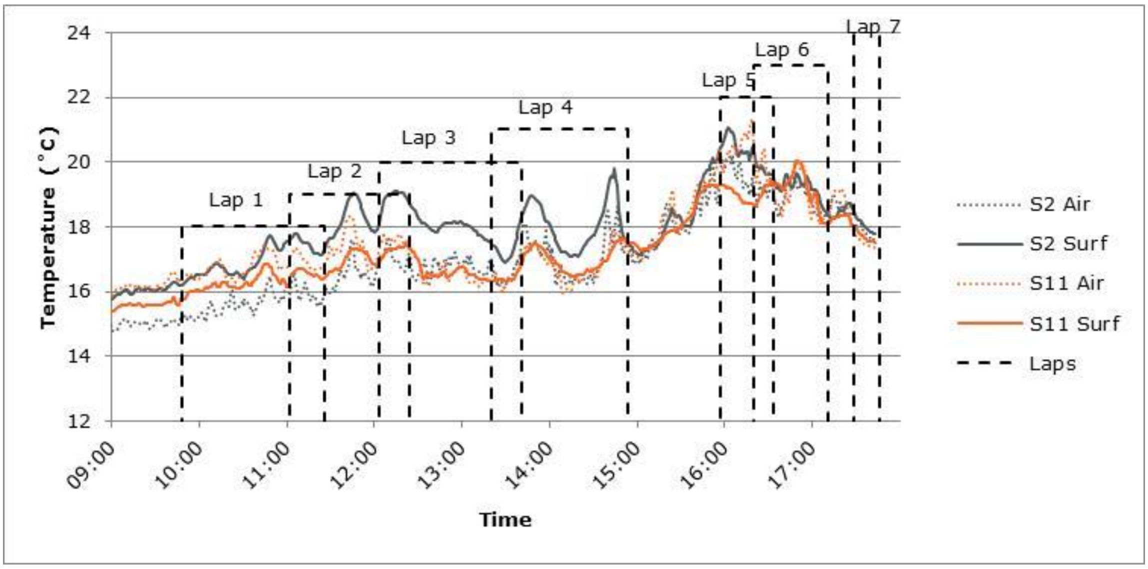

Figure 5.2: Air and surface temperatures during main trial day (Day 2)

Summaries of the pavement temperature measurements for each test lap are given in Table 5.1 and

Table 5.2 for stations 2 and 11 respectively.

Table 5.1: Pavement temperatures for each lap during Day 2, near station 2

Lap	Start of Lap			End of Lap			Lap Duration (Hours:mins)	Temperature difference during lap (˚ C)	
	Time	Temperature (˚C)		Time	Temperature (˚C)				
		40mm	100mm		40mm	100mm		40mm	100mm
1	09:48	17.2	14.3	11:26	17.5	15.2	01:38	0.3	0.9
2	11:02	17.4	15.1	12:24	18.6	15.8	01:22	1.2	0.7
3	12:03	17.8	15.6	13:41	17.9	15.9	01:38	0.1	0.3
4	13:20	17.8	15.9	14:54	18.8	16.6	01:34	1.0	0.7
5	15:57	21.5	17.5	16:34	21.2	17.5	00:37	-0.3	0.0
6	16:20	21.3	17.7	17:11	19.9	18.2	00:51	-1.4	0.5
7	17:29	19.8	18.2	17:46	19.3	18.2	00:17	-0.5	0.0

Table 5.2: Pavement temperatures for each lap during Day 2, near station 11

Lap	Start of Lap			End of Lap			Lap Duration (Hours:mins)	Temperature difference during lap (˚ C)	
	Time	Temperature (˚C)		Time	Temperature (˚C)				
		40mm	100mm		40mm	100mm		40mm	100mm
1	09:48	15.7	15.2	11:26	16.5	15.7	01:38	0.8	0.5
2	11:02	16.5	15.4	12:24	16.8	16.1	01:22	0.3	0.7
3	12:03	16.9	15.9	13:41	17.0	16.4	01:38	0.1	0.5
4	13:20	17.0	16.3	14:54	17.6	16.6	01:34	0.6	0.3
5	15:57	19.2	16.9	16:34	19.8	17.3	00:37	0.6	0.4
6	16:20	19.8	17.3	17:11	19.0	17.6	00:51	-0.8	0.3
7	17:29	19.0	17.7	17:46	18.7	17.6	00:17	-0.3	-0.1

It can be seen that the differences in 100mm depth temperatures between the start and end of laps ranged between -0.1˚C and 0.9˚C, significantly below the 3.0˚C limit. It is noted that there are differences in the temperatures recorded at the two stations, and it is believed that this is due to the differences in shading from trees throughout the day.

5.2 Reproducibility results from test laps

In order to evaluate the performance of each machine two laps are chosen from the test set: these laps are denoted lap i and lap ii. In general, the laps chosen for i and ii were laps 2 and 3 respectively (Note: the data from the warm up lap [lap 1] is always discarded). However, in some instances e.g. software failure, missed stations or machine alterations, this has resulted in different laps being selected. Some machines took part in additional laps along with some of the other machines to act as reference. The instances where laps 2 and 3 were not used or other issues were identified with the data for a lap are discussed below:

- **Machine 13.** During laps 1 and 2 this machine met the individual SDDR limit after the removal of a single data point. However on laps 3 and 4 this was no longer the case. The machine underwent investigation by the survey team and took part in lap 5 where the individual SDDR was still found to be out, and the mean FCF was no longer within the thresholds. The machine underwent further investigation and took part in laps 6 and 7. Laps 6 and 7 were used for laps i and ii.
- **Machine 15.** The data provided for this machine for lap 3 showed very high individual SDDR values (for geophone D7) which could not be resolved by removing a single data point. This machine performed suitably on lap 4 and it was therefore believed that the poor result on lap 3 was not characteristic of the device. This machine took part (and performed satisfactorily) in laps 5 and 6 to show that this was the case. Therefore laps 2 and 4 were used for laps i and ii.
- **Machine 32.** The data provided for this machine for lap 3 failed all of the FCF and SDDR criteria (both mean and individual). This was a noticeable difference to the performance seen in laps 1 and 2 and believed to be not characteristic of the device. This machine took part (and performed satisfactorily) in laps 5 and 6 to show that this was the case. Therefore laps 2 and 4 were used for laps i and ii.
- **Machine 33.** During the familiarisation lap this machine was found to be outside of the tolerances for the mean FCF. This was investigated on the inspection day and it appeared to be performing suitably in a repeat test on the same day. For laps 1 and 2 on the second day it was seen that the mean FCF was outside of the tolerances. This was communicated to the survey crew who made alterations prior to lap 3. This did not improve the results and a further adjustment was undertaken prior to lap 4. The results in lap 4 were within the tolerances and the machine took part in laps 5, 6 and 7. Therefore laps 6 and 7 were used for laps i and ii.
- **Machine 39.** During lap 4 (even though the assessment is typically based on laps 2 and 3, all machines take part in lap 4) an issue was noticed by the operator which was reflected in the SDDR values for this lap. This machine took part in laps 5 and 6 and this confirmed that the issue was localised to lap 4. Therefore laps 2 and 3 were used for laps i and ii.

The FCF and SDDR values derived from each machine’s laps are given in Appendix E, Table E.1. The laps chosen for assessment (lap i and ii) were laps 2 and 3 for most machines apart from the exceptions discussed above, as shown in Table 5.3.

Table 5.3: Machines for which laps 2 and 3 were not used for the assessment

Machine	Lap i	Lap ii
13	6	7
15	2	4
32	2	4
33	6	7

5.2.1 Plots of FCF and SDDR (prior to geophone removal)

The results from laps i and ii (prior to the removal of individual geophone readings) are shown graphically in Figure 5.3 for FCF and Figure 5.4 for SDDR. The vertical bars in these figures indicate the range of values from individual sensors and the filled circles/squares indicate the mean value for all seven sensors.

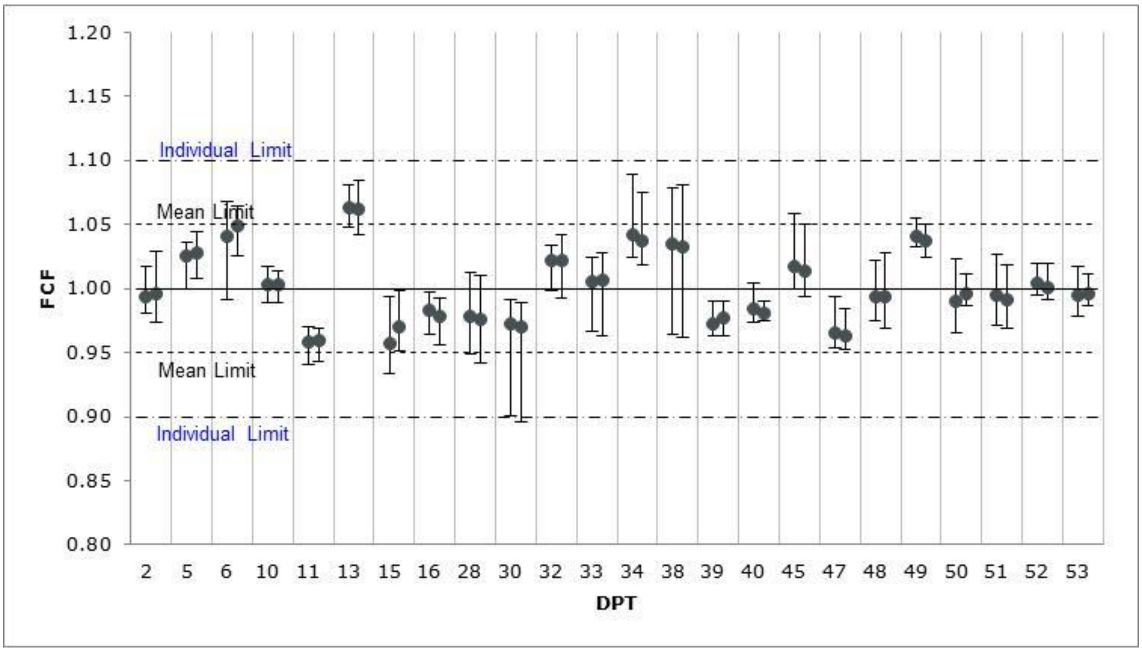

Figure 5.3: FCF for each DPT (main trial day for laps i and ii – full data set)

It can be seen from Figure 5.3 that one machine (Machine 13) fails to meet the mean Field Calibration Factor (FCF) criteria using the full data set from the two chosen test laps. In addition one machine (Machine 30) fails to meet the trial requirements for the individual geophone FCF values using the full set of data.

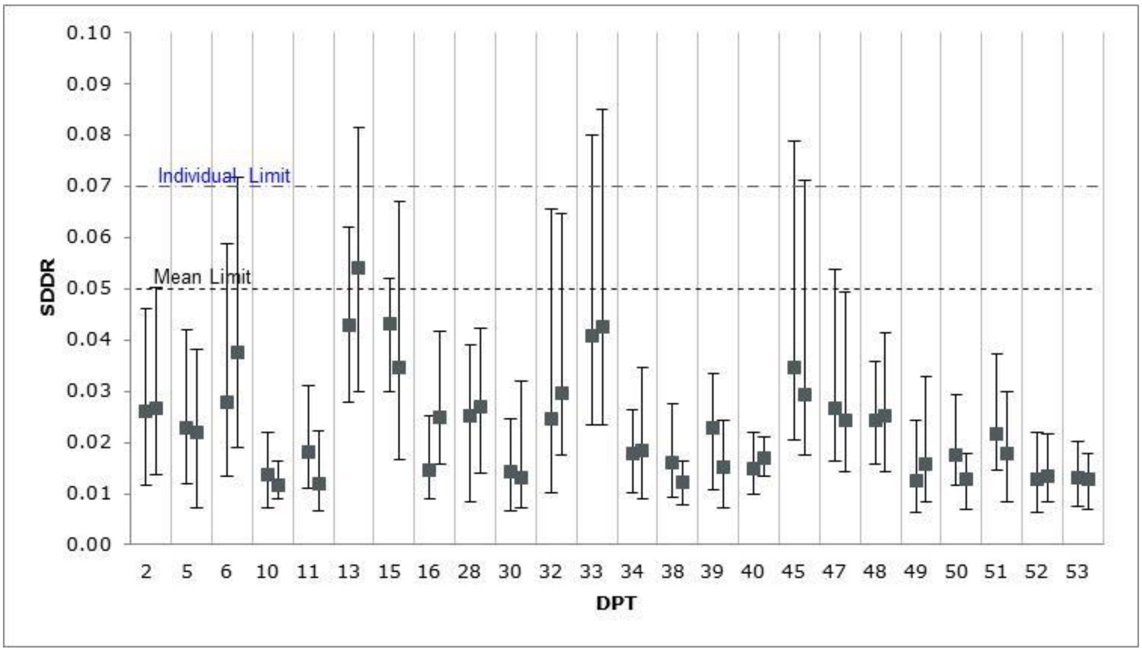

Figure 5.4: SDDR for each DPT (main trial day for laps i and ii – full dataset)

One machine (Machine 13) failed to meet the criterion for the mean SDDR using the full set of data. Four machines (Machines 6, 13, 33 and 45) failed to meet the individual SDDR criterion using the full set of data.

5.2.2 *Plots of SDDR (after geophone removal)*

The results from laps i and ii (after geophone removal for identified machines) are shown graphically in Figure 5.5 for FCF and Figure 5.6 for SDDR.

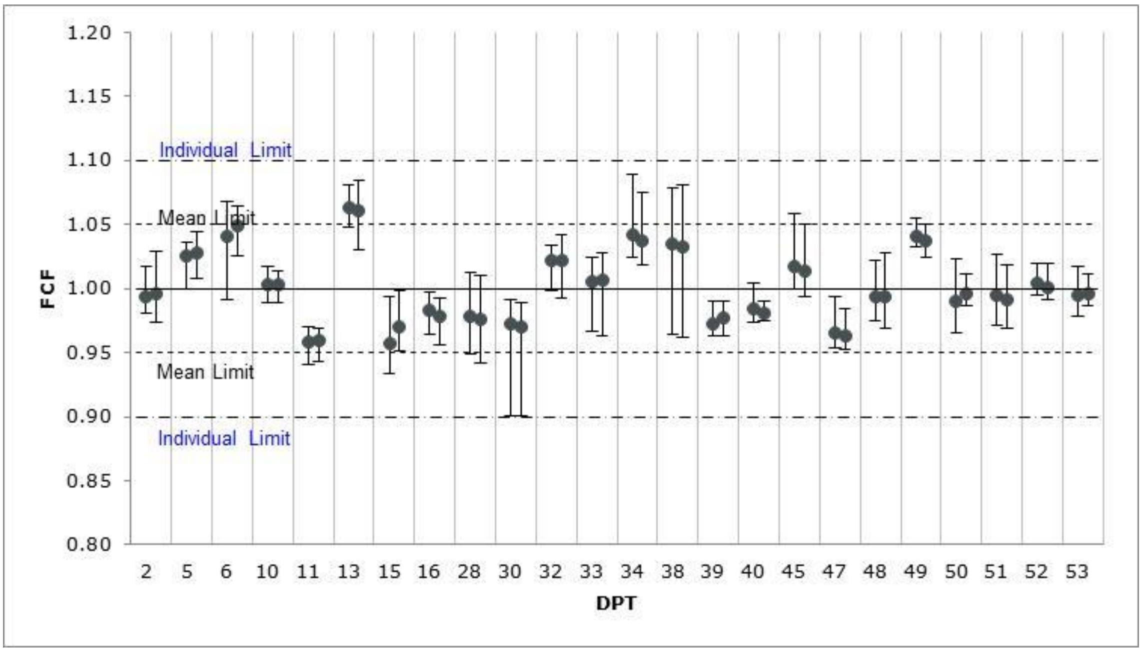

Figure 5.5: FCF for each DPT (main trial day for laps i and ii – single data point removed)

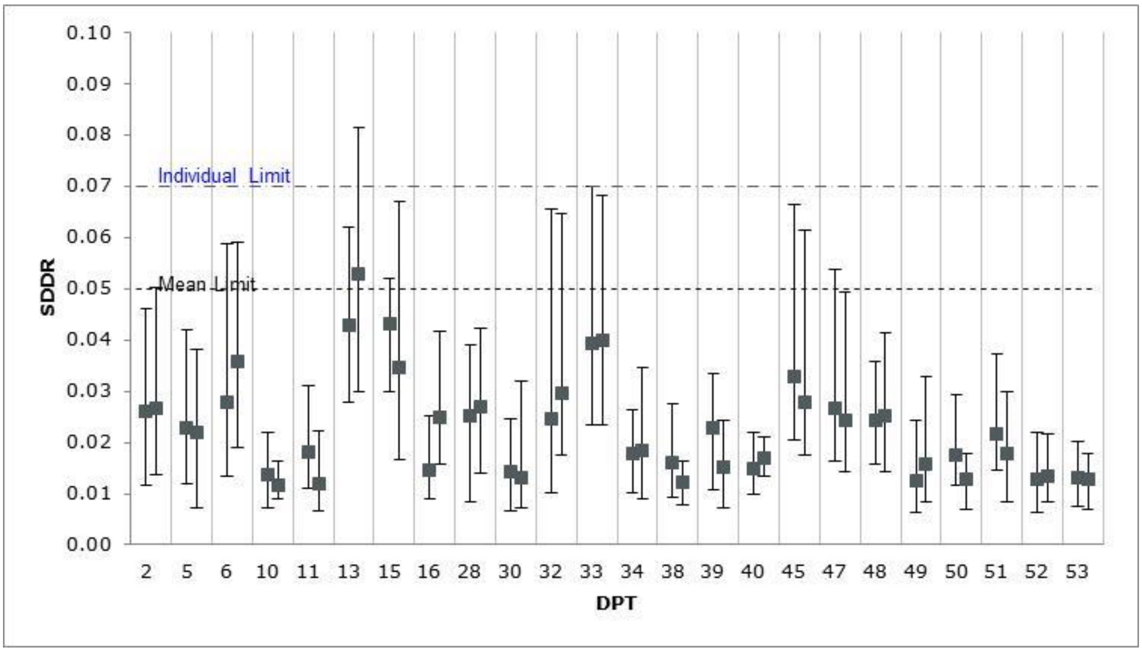

Figure 5.6: SDDR for each DPT (main trial day for laps i and ii – single data point removed)

Following the removal of a single geophone reading from one station on each lap it can be seen that Machine 13 still fails to meet the mean FCF criteria. Machine 30 now meets the individual FCF criteria.

Even after removal of a single geophone reading from one station on each lap it can be seen that Machine 13 does not meet the mean SDDR criteria or the individual SDDR criteria. Machines 6, 33 and 45 now meet the individual SDDR criteria.

Therefore, in summary, 1 of the 24 machines (Machine 13) fails to meet the reproducibility criteria after the test laps on the main trial day.

5.3 Distance measurement tests

In order to assess the measurement of distance, the operators were asked to provide four distance measurements of a specified length. The distance covered by this length, 512.1m, was not provided to the operators. The criteria applied to this data are described in section 3.1. The differences between the operator measurements and the reference length are given in Table 5.4 (negative denotes the operator recorded a shorter length). In this table the data is shown in grey if the difference measured was within or equal to 1m of the reference, and highlighted in bold and red font if the difference measured was greater than the tolerance (1% i.e. 5.1m). A machine would fail this test if it could not supply all four measured lengths within the criteria.

Table 5.4: Difference between operators' measured values and reference

Machine	Difference between measured distance and reference (m)				Performance
	Lap a	Lap b	Lap c	Lap d	
2	-1.0	-1.0	-1.0	-1.0	Pass
5	-1.5	-1.5	-1.5	-1.5	Pass
6	-0.8	-0.5	-0.8	-0.8	Pass
10	-1.0	-1.0	-1.0	-1.0	Pass
11	-2.0	-2.0	-2.0	-2.0	Pass
13	-2.0	-2.0	-2.0	-2.0	Pass
15	1.0	0.0	0.0	0.0	Pass
16	0.0	0.0	0.0	0.0	Pass
28	-1.0	-1.0	-1.0	-1.0	Pass
30	-1.0	-1.0	-1.0	-1.0	Pass
32	-2.0	-2.0	-2.0	-2.0	Pass
33	-1.0	-1.0	-1.0	-1.0	Pass
34	.-1.0	-1.0	-1.0	-1.0	Pass
38	-1.0	-1.0	-1.0	-1.0	Pass
39	-1.6	-1.5	-1.6	-1.5	Pass
40	-4.0	-4.0	-4.0	-4.0	Pass
45	-2.0	-1.0	-1.0	-1.0	Pass
47	-0.5	-0.5	-0.6	-0.6	Pass
48	-1.5	-1.3	-1.5	-1.6	Pass
49	-1.0	-1.0	-1.0	-1.0	Pass
50	-4.0	-5.0	-3.0	-4.0	Pass
51	-2.0	-2.0	-3.0	-2.0	Pass
52	-3.0	-3.0	-3.0	-3.0	Pass
53	-1.0	-1.0	-1.0	-1.0	Pass

It can be seen from this table that all machines met the trial criteria. In addition, 57% of the measurements were within 1m of the reference distance.

5.4 OSGR measurements (from 3-dimensional position data)

3-dimensional position data were supplied by 13 of the 24 machines at the trial. These devices all provide the data in lat/long/height format. Therefore the data has been converted to OSGR format (eastings and northings) by TRL before assessment against the criteria (given in section 3.2). It is worth noting that other types of survey devices that operate on the Highways England network provide their data in OSGR format and as such consideration should be given to imposing the requirement of providing the data in OSGR format.

The percentage of the data within 2m, 5m and 10m for each of the machines that supplied positional data is given in Table 5.5. This data is highlighted in bold and red text if the percentage is below 75% for any of the criteria.

Table 5.5: Assessment of positional data

Machine	Percentage of data that is within x m of the reference (horizontally)			Performance band
	2m	5m	10m	
5	96%	100%	100%	High
6	96%	100%	100%	High
10	54%	63%	83%	Low
28	96%	100%	100%	High
30	75%	98%	98%	Medium
34	0%	0%	0%	Not Suitable
38	19%	31%	65%	Not Suitable
39	80%	100%	100%	High
40	75%	100%	100%	Medium
47	98%	100%	100%	High
49	65%	100%	100%	Medium
50	54%	100%	100%	Medium
53	77%	100%	100%	High

5.5 Operator temperature measurements

The DPT operators were asked to use their own equipment to record temperatures from two pre-drilled holes so that the accuracy of temperature collection could be assessed. These holes are drilled to 100mm depth and located near stations 2 and 11. The temperatures recorded by the operators are plotted against the data recorded from the temperature data logger (located in the same hole) in Figure 5.7 and Figure 5.8.

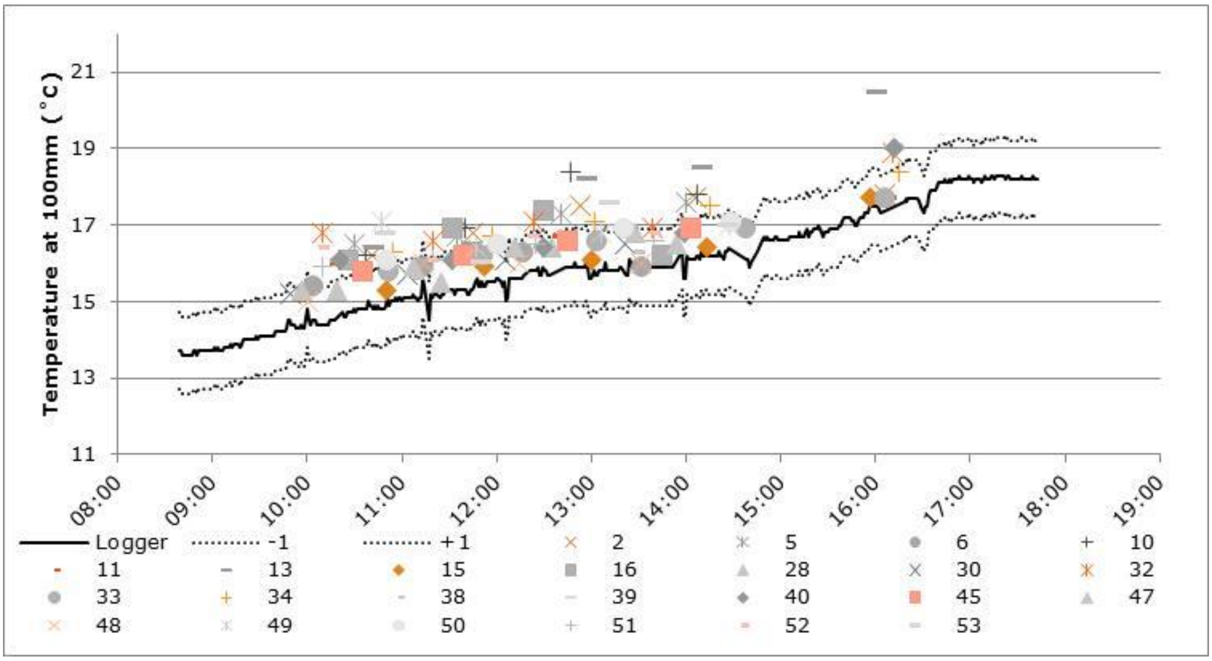

Figure 5.7: Comparison of operator's temperatures and logger temperatures (day 2 near station 2, 100mm depth)

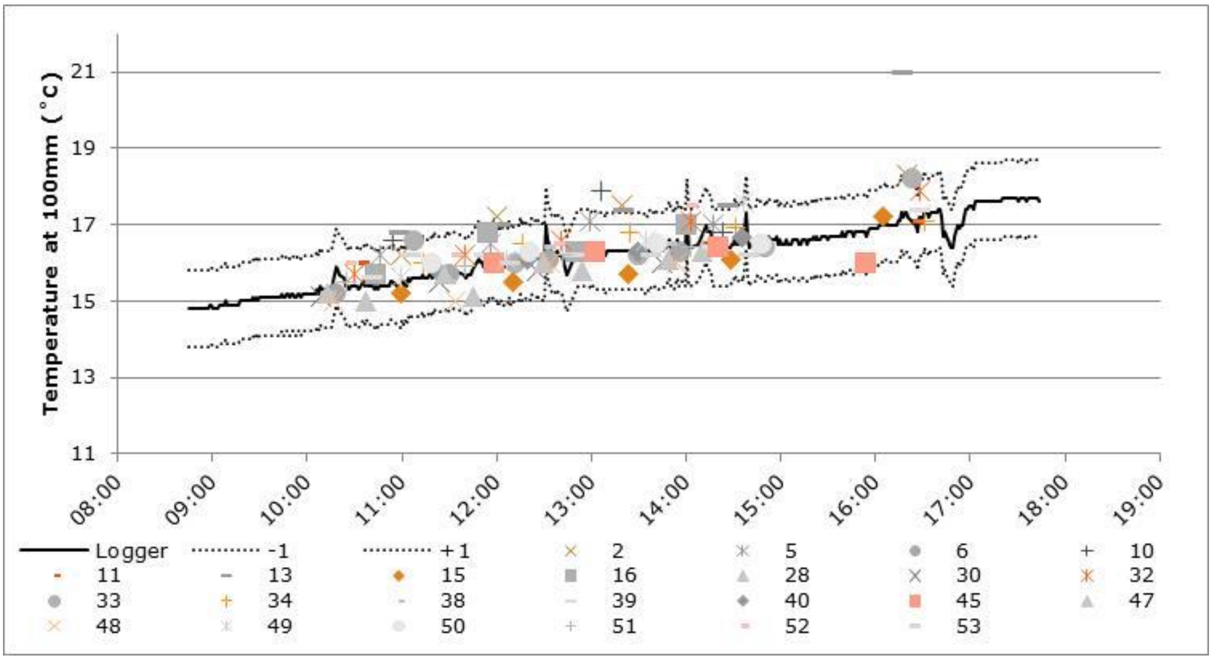

Figure 5.8: Comparison of operator's temperatures and logger temperatures (day 2 near station 11, 100mm depth)

It can be seen from these two plots that the operators' measurements are generally consistent with the logger measurement. However, there is a noticeable difference in the performance seen on station 2 in comparison to station 11. It is not known what the causes for these differences are however this difference was also observed in previous trials. However in previous trials the offset was seen on station 11 rather than on station 2. This has been investigated but no cause was identified. This should be monitored at future trials to see if the cause can be identified.

The test criteria for temperature measurement at depth are given in section 3.2, and the machines were assessed using data from four laps. The differences and ratings given are presented in Table 5.6. In the table values are highlighted in bold and red font if the value was more than 1˚C away from the reference.

Table 5.6: Assessment of operators' temperature measurement at depth (stations 2 & 11)

Machine	Difference between operators' measurement and reference data (˚C)								Percentage within 1˚C	Rating
	Lap a		Lap b		Lap c		Lap d			
	2	11	2	11	2	11	2	11		
2	**1.3**	0.9	**1.5**	**1.3**	**1.6**	**1.2**	**1.6**	-0.3	25%	Low
5	**1.7**	0.8	**1.4**	0.5	**1.6**	0.7	**2.0**	0.6	50%	Low
6	0.9	-0.1	0.8	0.0	0.7	-0.5	0.0	-0.1	100%	High
10	**1.4**	**1.1**	**1.6**	0.9	**2.5**	**1.6**	**1.7**	0.4	25%	Low
11	**1.5**	0.7	1.0	-0.2	0.8	0.0	0.4	-0.1	88%	High
13	**1.6**	**1.3**	**1.2**	**1.1**	**2.2**	**1.1**	**2.4**	**1.1**	0%	Not Suitable
15	0.5	-0.1	0.4	-0.4	0.5	-0.6	0.2	-0.3	100%	High
16	**1.4**	0.4	**1.6**	0.9	**1.5**	0.6	0.3	0.6	63%	Medium

Machine	Difference between operators' measurement and reference data (˚C)								Percentage within 1˚C	Rating
	Lap a		Lap b		Lap c		Lap d			
	2	11	2	11	2	11	2	11		
28	0.8	-0.4	0.4	-0.7	0.7	-0.6	0.6	-0.2	100%	High
30	0.7	-0.3	0.6	-0.2	0.6	-0.3	0.6	-0.3	100%	High
32	**2.4**	0.3	**1.5**	0.5	**1.3**	0.4	1.0	0.7	63%	Medium
33	0.9	1.0	0.8	0.0	0.8	-0.1	0.5	-0.2	100%	High
34	**1.3**	0.3	**1.2**	0.5	**1.4**	0.5	**1.3**	0.2	50%	Low
38	0.9	-0.1	0.4	-0.2	0.7	0.4	0.4	0.1	100%	High
39	**1.6**	0.2	0.8	0.3	0.5	0.5	**1.2**	-0.4	75%	Medium
40	0.8	0.1	0.8	0.1	1.0	0.0	0.8	0.0	100%	High
45	1.0	-0.8	0.9	-0.1	0.7	-0.1	0.8	0.0	100%	High
47	0.9	-0.1	0.7	0.0	0.8	0.0	0.9	-0.4	100%	High
48	0.2	-0.3	0.4	-0.8	0.4	-0.6	0.1	-0.3	100%	High
49	**2.3**	0.3	0.9	0.2	1.0	0.4	0.6	**1.1**	75%	Medium
50	**1.3**	0.3	0.9	0.3	1.0	0.2	0.7	-0.1	88%	High
51	**1.5**	0.1	1.0	0.2	0.7	0.0	0.7	0.0	88%	High
52	**2.0**	0.6	**1.3**	0.4	1.0	0.3	0.9	0.3	75%	Medium
53	**2.0**	0.7	0.5	-0.1	**1.8**	-0.2	0.7	-0.4	75%	Medium

It can be seen from this table that thirteen machines achieved the high performance rating, six machines achieved a medium performance, four machines achieved a low performance and one machine was identified as not suitable.

5.5.1 Contactless surface and air temperature measurements

A methodology for estimating the temperature at 100mm has been developed but is not yet formally implemented in the Design Manual for Roads and Bridges. This method uses the surface temperature at the time of the survey (collected using on-board IRT sensors on the DPT) and the average air temperature for the previous day (acquired from a weather station). Due to this new methodology a number of contractors have fitted sensors for the automatic measurement of air and surface temperatures to their survey devices.

5.5.1.1 Contactless surface temperature measurements

Of the twenty-four machines which took part in the trial, eleven machines (34, 38, 39, 40, 45, 47, 48, 50, 21, 52 and 53) had surface temperatures in their datasets which changed during testing (i.e. not fixed default values). The surface temperature data from station 2 and 11 for these machines is shown along with surface temperature data from the logger in Figure 5.9 and Figure 5.10 respectively.

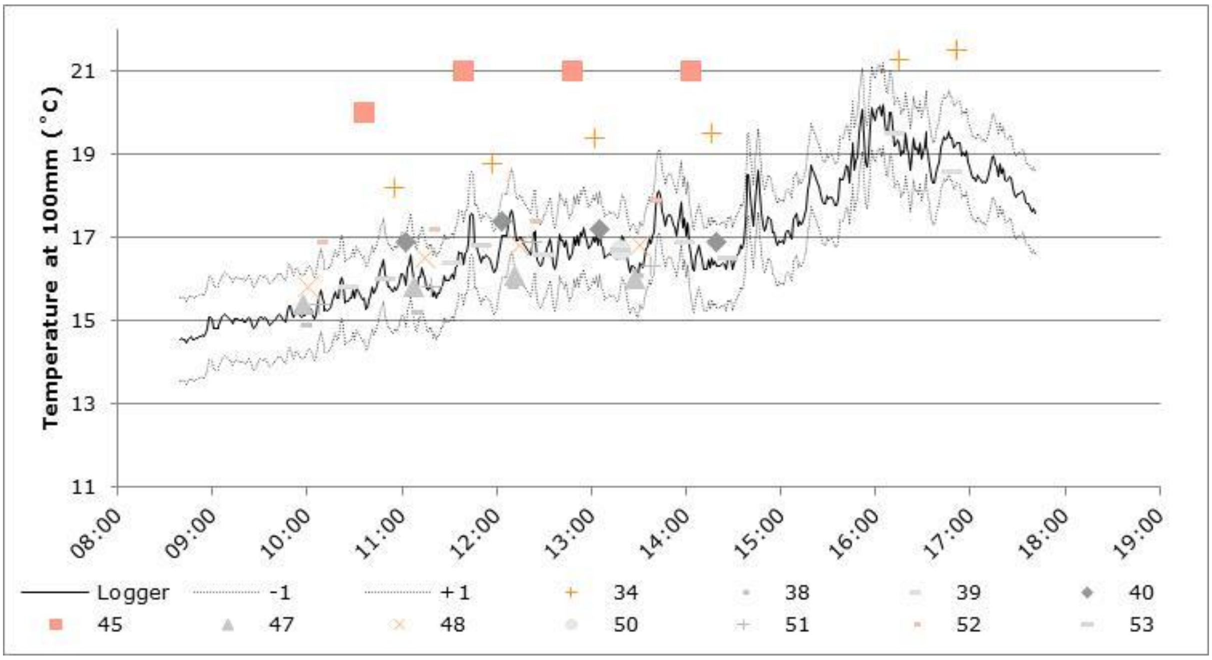

Figure 5.9: Comparison of surface temperatures recorded by DPTs and reference logger measurements (day 2 near station 2)

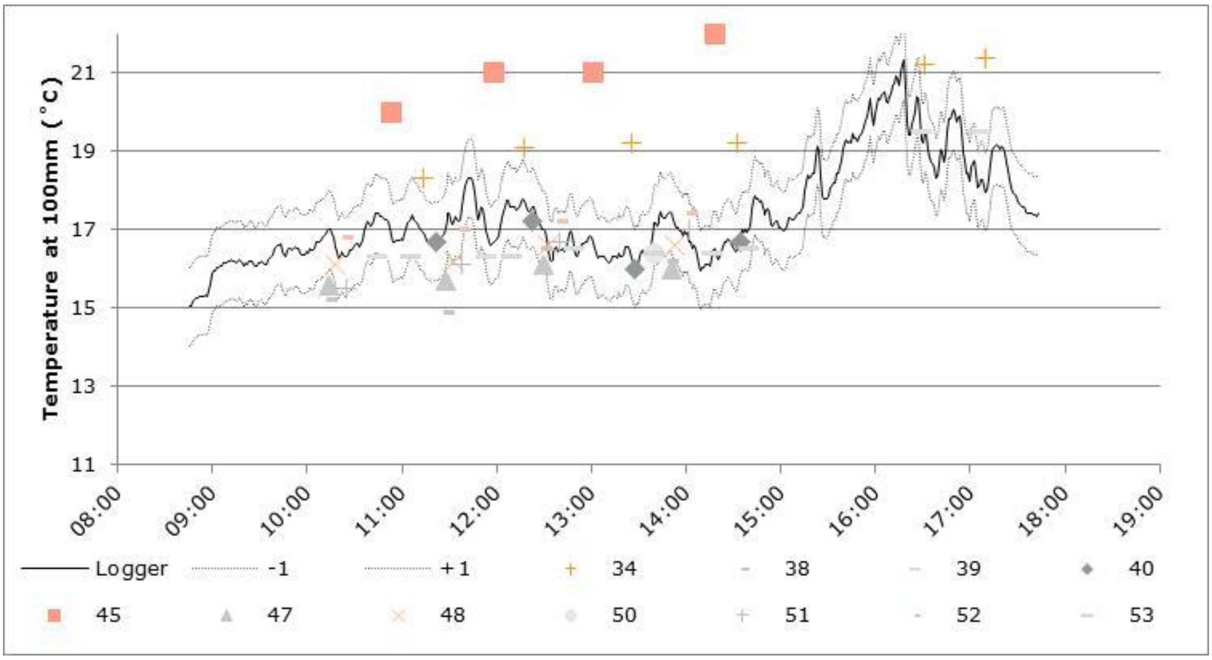

Figure 5.10: Comparison of surface temperatures recorded by DPTs and reference logger measurements (day 2 near station 11)

The test criteria for surface temperature measurement are given in section 3.2, and the machines were assessed using the data from 4 laps. The differences and ratings given are presented in Table 5.7. In the table values are highlighted in bold and red font if the value was more than 1˚C away from the reference.

Table 5.7: Assessment of operators’ surface temperature measurement against logger

Machine	Difference between operators’ measurement and reference data (˚C)								Percentage within 1˚C	Rating
	Lap A		Lap B		Lap C		Lap D			
	2	11	2	11	2	11	2	11		
34	0.9	**1.7**	0.7	**1.7**	**1.3**	**2.8**	**2.4**	**2.5**	25%	Low
38	**-1.5**	-0.9	**-2.6**	**-1.6**	**-3.1**	-0.6	-1.0	**-1.3**	38%	Low
39	-0.8	-0.4	**-1.3**	-0.9	**-1.8**	0.0	**-1.3**	-0.1	63%	Medium
40	-0.7	0.2	-0.7	-0.2	-0.8	-0.4	-0.2	-0.1	100%	High
45	**3.3**	**3.5**	**2.7**	**4.0**	**2.9**	**4.2**	**3.2**	**5.5**	0%	Not Suitable
47	**-1.1**	-0.6	**-2.0**	-0.8	**-2.9**	-0.9	-1.0	**-1.5**	50%	Low
48	-0.7	-0.2	-1.0	-0.5	**-2.3**	0.0	-0.1	-0.8	88%	High
50	**-52.3**	**-51.6**	**-52.9**	**-52.4**	-0.9	-0.3	**-52.7**	**-52.6**	25%	Low
51	**-1.3**	-0.6	**-1.4**	-0.6	**-2.0**	0.2	**-1.4**	0.0	50%	Low
52	0.3	0.6	-0.1	0.3	**-1.6**	0.7	0.2	0.4	88%	High
53	**-1.7**	-0.3	**-2.0**	-1.0	-0.9	-0.3	**-1.1**	-0.4	63%	Medium

From these results it can be seen that three machines meet the high performance level, two meet the medium performance level, five meet the low performance level and one has been identified as not suitable. It is also worth noting that one machine (Machine 50) varied from very low unrealistic levels (-35˚C) to levels very close to the reference data. This machine has been awarded a low performance based on these results, however it suggests that it could perform much better than this and was suffering from an intermittent fault.

5.5.1.2 Air temperature measurements

Thirteen machines (6, 32, 34, 38, 39, 40, 45, 47, 48, 49, 50, 51, and 52) provided air temperatures in their datasets which changed during testing. The air temperature data from station 2 and 11 for these machines is shown along with air temperature data from the logger in Figure 5.11 and Figure 5.12 respectively. Note that the data from Machine 45 was consistently much lower than the rest of the fleet and does not appear within the scale shown in the graphs.

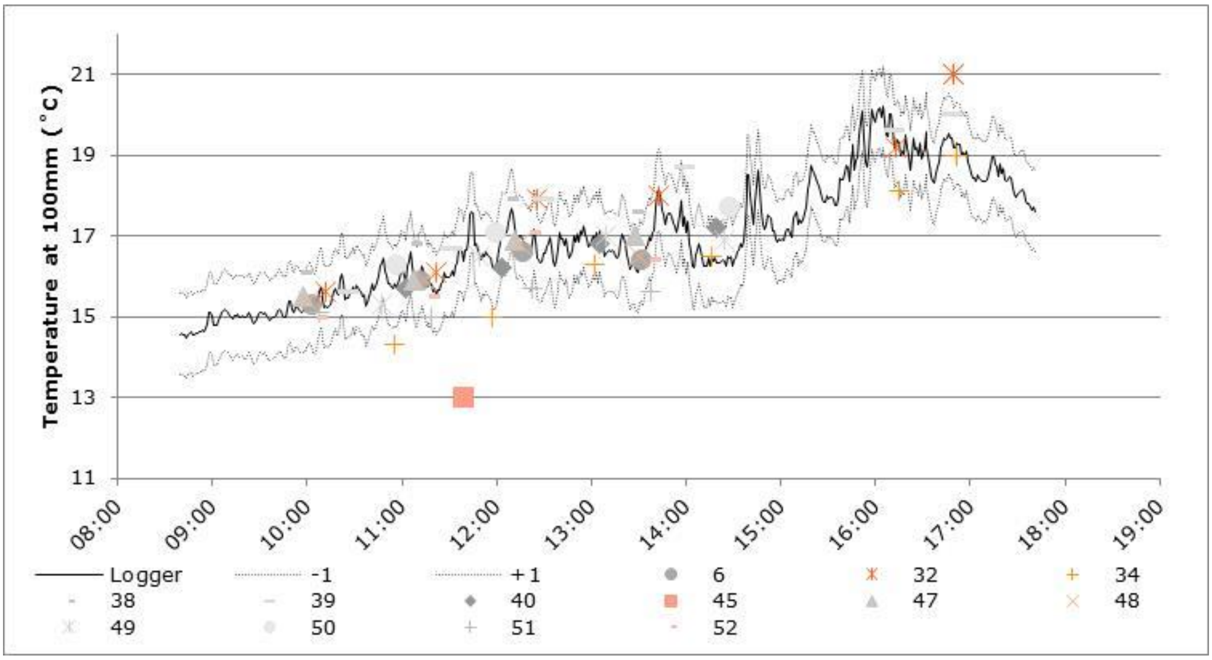

Figure 5.11: Air temperatures recorded by DPTs and reference logger measurements (day 2 near station 2)

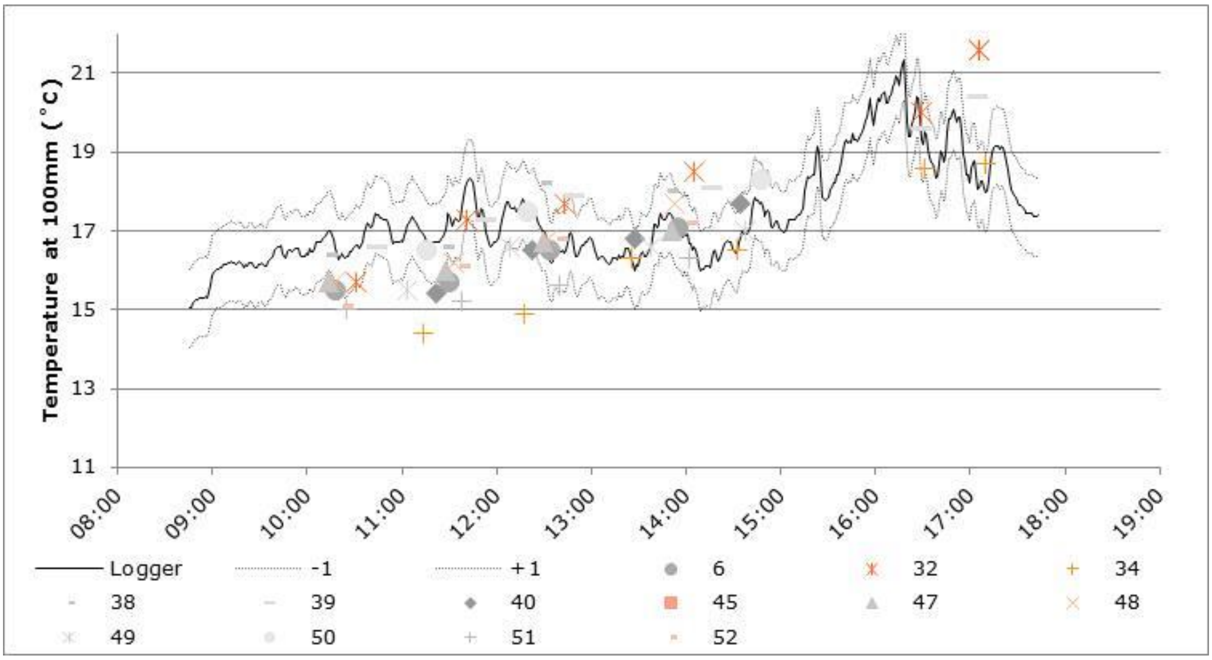

Figure 5.12: Air temperatures recorded by DPTs and reference logger measurements (day 2 near station 11)

Although the air temperature measurements from DPTs at the time of testing are not used for the contactless 100mm temperature calculation method, it seemed prudent to assess the data supplied from the machines. There are no formal criteria set for this measurement, therefore the data has been assessed against the surface temperature measurement criteria (given in section 3.2). The differences between the data and the fleet average, and the ratings given are presented in Table 5.7. In the table values are highlighted in bold and red font if the value was more than 1˚C away from the reference.

Table 5.8: Assessment of operators' air temperature measurement

Machine	Difference between operators' measurement and reference data (˚C)								Percentage within 1˚C	Rating
	Lap A		Lap B		Lap C		Lap D			
	2	11	2	11	2	11	2	11		
6	0.0	**-1.1**	-0.2	**-1.7**	-0.3	0.3	0.0	0.0	75%	Medium
32	0.4	-0.9	0.4	-0.8	1.0	**1.2**	0.0	0.7	88%	High
34	**-1.5**	**-2.5**	**-1.4**	**-2.8**	-0.7	0.0	0.0	0.0	50%	Low
38	1.0	-0.6	0.6	-0.3	0.6	**1.2**	**1.3**	0.6	75%	Medium
39	0.1	-0.8	0.7	0.0	**1.5**	**1.1**	-0.1	0.3	75%	Medium
40	-0.2	**-1.3**	-0.9	**-1.1**	0.0	0.8	0.9	0.9	75%	Medium
45	**-13.5**	**-7.0**	**-3.6**	**-6.6**	**-8.5**	**-7.8**	**-9.8**	**-9.5**	0%	Not Suitable
47	0.4	**-1.3**	-0.1	**-1.0**	-0.3	-0.3	0.7	-0.5	75%	Medium
48	0.1	-0.9	-0.1	-0.9	-0.2	0.3	0.1	0.4	100%	High
49	-0.9	**-1.7**	-0.2	-1.0	0.4	0.0	0.5	0.0	88%	High
50	0.6	-0.2	0.9	0.0	.	.	**1.2**	0.6	83%	High
51	-0.5	**-1.3**	-0.8	**-2.1**	**-1.1**	-0.8	**-1.4**	-0.6	50%	Low
52	-0.4	**-1.3**	-0.4	**-1.1**	0.5	0.2	-0.6	0.3	75%	Medium

From these results it can be seen that 4 machines meet the high performance level, six meet the medium performance level, two meet the low performance level and one is identified as not suitable.

6 Summary of trial findings

The 2019 UK DPT accreditation trial was held at Horiba-MIRA between the 24th and 25th September 2019. Twenty-four machines took part in the trial.

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

(i) Repeatability of Deflections

- All twenty-four machines met the trial requirements for the Repeatability assessment.

(ii) Reproducibility of Deflections

- Twenty-three of the twenty-four machines met the trial requirements for the mean Field Calibration Factor (FCF).
- All twenty-four machines met the trial requirements for the individual geophone Field Calibration Factors (FCF).
- Twenty-three of the twenty-four machines met the trial requirements for the mean Standard Deviation of the Deviation Ratio (SDDR).
- Twenty-three of the twenty-four machines met the trial requirements for the individual Standard Deviation of the Deviation Ratio (SDDR).

(iii) Distance measurement

- All twenty-four machines met the trial requirements for distance assessment.

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

(iv) OSGR Co-ordinates

- Thirteen machines provided 3-dimensional position data in lat/long/height format. After conversion of the data into OSGR format (by TRL), six machines were identified as having achieved a high performance level, four a medium performance level, one a low performance level and two were identified as not suitable. The contractors' coordinate transformation to OSGR format was not assessed. It is worth noting that other types of survey devices that operate on the Highways England network provide their data in OSGR format and as such consideration should be given to imposing the requirement of providing the data in OSGR format.

(v) Temperature measurement at depth (100mm)

- All twenty-four machines provided 100mm pavement temperature measurements using hand held probes. Thirteen machines achieved a high performance level, six a medium, four a low and one not suitable.

(vi) Surface temperature measurement

- Eleven machines provided surface temperature measurements using IRTs fixed to their machines. Three machines achieved a high performance level, two a medium, five a low and one not suitable.

(vii) Air temperature measurement

- Thirteen machines provided air temperature measurements from apparatus fixed to their machines. Using the surface temperature criteria, four machines achieved a high performance level, six a medium, two a low and one was identified as not suitable.

In summary, twenty-three of the twenty-four machines that participated in the 2019 accreditation trial fully met the mandatory requirements of the trial.

The outcome of the trial for each machine, against both the mandatory and non-mandatory criteria, is summarised in Appendix F.

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Appendix A Machine details table

ID	Owner	Make, model and serial number	Trailer or vehicle mounted?	No of weights / buffers per side	Plate type	Date of last tower calibration	Date of last dynamic calibration	Date of last manufacturer calibration
2	AECOM Ltd.	Dynatest FWD 8002 SN 102	Trailer	6/3	Solid	13/06/2019	23/09/2019	27/08/2019
5	AECOM Ltd.	Dynatest HWD 8082 SN 050	Trailer	2/5	2-way Segmented	Not provided	23/09/2019	Not provided
6	PMS Ltd.	Dynatest HWD 8082 SN 018	Trailer	0/5	Solid	17/04/2019	02/08/2019	20/09/2019
10	AECOM Ltd.	Dynatest FWD 8002 SN 192	Trailer	6/3	2-way Segmented	13/06/2019	23/09/2019	11/09/2019
11	Pulse Surveying Ltd.	Dynatest FWD 8002 SN 187	Trailer	4/2	Solid	15/04/2019	22/08/2019	16/07/2019
13	AECOM Ltd.	Dynatest HWD 8082 SN 029	Trailer	2/5	Solid	13/06/2019	23/09/2019	21/09/2019
15	CET Infrastructure	Dynatest FWD 8002 SN 203	Trailer	6/3	2-way Segmented	Sep-19	Sep-19	Sep-19
16	PTS	Dynatest FWD 8002 SN 214	Trailer	4/2	2-way Segmented	Sep-19	Sep-19	Sep-19
28	Pulse Surveying Ltd.	Dynatest FWD 8002 SN 271	Trailer	4/2	Solid	15/04/2019	21/08/2019	08/07/2019
30	PMS Ltd.	Dynatest FWD 8002 SN 173	Trailer	4/2	Solid	15/04/2019	09/08/2019	03/04/2019

ID	Owner	Make, model and serial number	Trailer or vehicle mounted?	No of weights / buffers per side	Plate type	Date of last tower calibration	Date of last dynamic calibration	Date of last manufacturer calibration
32	PTS	Dynatest HWD 8082 SN 069	Trailer	0/5	2-way Segmented	Sep-19	Sep-19	Sep-19
33	PTS	Dynatest HWD 8082 SN 070	Trailer	0/5	Solid	Sep-19	Sep-19	Sep-19
34	PTS	Dynatest HWD 8082 SN 108	Trailer	0/5	4-way Segmented	Sep-19	Sep-19	Aug-19
38	Milestone Pavement Technologies	Grontmij PRI 1500 1111-448	Trailer	3/4	4-way Segmented	Sep-19	Sep-19	Sep-19
39	TRL	Dynatest FWD 8002 SN 388	Trailer	6/3	2-way Segmented	06/08/2019	08/08/2019	05/06/2019
40	Dynatest	Dynatest FFWD 8012 SN 002	Trailer	4/2	4-way Segmented	18/06/2019	18/09/2019	18/02/2019
45	Atlas Geophysical	Grontmij Carlbro PRI2100 0903-088	Trailer	4/4	Solid	26/09/2019	26/09/2019	26/09/2019
47	PMS Ltd.	Dynatest FWD 8002 SN 452	Trailer	4/2	4-way Segmented	22/03/2019	05/09/2019	06/08/2019
48	Balfour Beatty	Dynatest FWD 8002 SN 424	Trailer	4/2	4-way Segmented	04/12/2018	18/08/2019	24/01/2019
49	Dynatest	Dynatest FWD 8082 SN 146	Trailer	0/4	4-way Segmented	19/07/2019	18/09/2019	19/07/2019
50	SOCOTEC	RINCENT HeavyDyn HVY-101A	Trailer	10/4	Solid	16/05/2019	19/09/2019	15/03/2018

ID	Owner	Make, model and serial number	Trailer or vehicle mounted?	No of weights / buffers per side	Plate type	Date of last tower calibration	Date of last dynamic calibration	Date of last manufacturer calibration
51	James Fisher Testing	Grontmij FWD PRI2500 0415-490	Trailer	3/4	4-way Segmented	16/09/2019	n/a (new machine)	15/07/2019
52	James Fisher Testing	Dynatest FFWD 8012 SN 057	Trailer	4/2	4-way Segmented	18/09/2019	n/a (new machine)	10/09/2019
53	Dynatest	Dynatest FWD 8002 SN 098	Trailer	4/2	4-way Segmented	20/09/2019	n/a (new machine)	20/09/2019

Appendix B Photographs of machines taken at previous trials

Figure B.1: Dynatest 8002 FWD

Figure B.2: Dynatest 8082 FWD

Figure B.3: Grontmij Primax 2100 HWD

Figure B.4: Grontmij Primax 1500 HWD

Appendix C Construction details for the Highways England reference site at Horiba-MIRA proving ground

Table C.1: Design construction of Highways England reference site

Section	Test points	Nominal construction details and material type (mm)				
		Surface course	Binder course	Base	Total asphalt thickness [mm]	Sub-base
1	1-3	30 TSC	235 EME2		270	200mm C8/10 HBM
2	4-6	35 TSC	170 DBM		200	250mm 6F1 granular capping material
3	7-9	30 TSC	170 EME2		200	200 Type 1 granular material
4	10-12	35 TSC	35 Axo	230 JRC	70	150-175 Hoggin
Notes	TSC = Cl 942 Thin Surface Course EME2 = Enrobé à Module Élevé, DBM = Dense Bitumen Macadam, Axo = Axoshield, HBM = Hydraulically Bound Material, JRC = Jointed reinforced concrete, 6F1 = Selected granular capping.					

Table C.2: Construction details of Highways England reference site from cores

Section	Test points	Post Construction Results from cores (mm)			
		Surface course	Binder/ Binder+ base courses	Total asphalt thickness [mm]	Base/Sub-base (mm)
1	1-3	42 TSC	228	270	217 (HBM sub-base)
2	4-6	37 TSC	158	192	-
3	7-9	35 TSC	191	226	-
4	10-12	30 TSC	36 Axo	66	194 (JRC base)
Notes	TSC = Cl 942 Thin Surface Course , HBM = Hydraulically Bound Material, JRC = Jointed reinforced concrete, Axo= Axoshield				

Table C.3: Construction details of Highways England reference site from GPR

Section	Test points	Post Construction layer information results from GPR (in mm)			
		Minimum	Average	Maximum	Material
1	1-3	192 166 388	242 188 431	272 215 468	Asphalt HBM Total bound thickness
2	4-6	167	192	240	Asphalt
3	7-9	167	199	240	Asphalt
4	10-12	47	65	76	These results are for the bitumen-bound surfacing. No lower GPR trace due to steel reinforcement.
Notes	HBM = Hydraulically Bound Material				

Appendix D Repeatability trial data

Data is highlighted in bold red text if it does not meet the criteria (for a valid test or for the assessment). Laps not used in the assessment are shown in italics and grey text (apart from the data points which exceed the criteria).

D.1 Machine 2

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	706.8	0.4%	74	63	57	50	42	35	23	1.2	0.6	0.2	0.3	0.4	0.2	0.3
	5	686.1	0.3%	535	415	263	152	86	51	35	1.4	0.7	0.5	0.8	0.2	0.4	0.9
	8	699.2	0.4%	260	228	181	132	96	68	37	0.9	0.5	0.4	0.7	0.2	0.4	0.7
	13	706.4	0.3%	130	119	102	85	69	54	39	0.9	0.4	0.4	0.1	0.2	0.8	0.8
2	2	725.9	0.3%	78	63	56	50	41	35	23	0.5	0.7	0.4	0.3	**2.3**	0.1	0.8
	5	700.5	0.2%	527	420	265	157	87	51	34	0.8	0.4	0.5	0.3	0.3	0.8	0.5
	8	713.4	0.3%	263	229	182	136	95	65	34	0.8	0.3	0.3	0.2	0.3	0.4	0.2
	13	716.9	0.3%	129	114	97	80	63	53	35	1.2	0.4	0.4	0.5	1.4	0.8	0.6

D.2 Machine 5

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	719.4	0.5%	72	59	53	46	40	32	21	0.3	0.4	0.4	0.2	0.5	0.3	0.3
	5	718.8	0.2%	510	406	257	154	89	58	38	0.9	1.3	0.9	0.6	0.6	0.4	0.4
	8	717.5	0.5%	247	217	172	129	93	66	32	1.0	0.9	0.7	0.6	0.4	0.6	0.5
	13	704.7	0.3%	122	108	93	77	61	49	34	0.3	0.4	0.3	0.3	0.5	0.3	0.3
2	2	768.4	1.5%	71	59	53	46	39	32	22	0.4	0.4	0.2	0.2	0.2	0.2	0.1
	5	766.8	0.4%	523	411	260	154	91	57	37	2.2	1.6	1.6	0.7	0.5	0.6	0.9
	8	755.9	1.1%	245	215	171	130	93	66	34	0.9	0.8	0.5	0.6	0.3	0.6	0.2
	13	736.7	1.4%	119	107	92	75	61	48	31	0.6	0.3	0.2	0.2	0.1	0.4	0.5

D.3 Machine 6

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	711.8	0.6%	71	58	52	45	38	32	22	0.3	0.2	0.3	0.3	0.2	0.3	0.3
	5	702.9	0.2%	502	396	255	153	89	54	39	0.8	0.4	1.0	0.7	0.5	0.3	0.6
	8	701.1	0.2%	241	207	168	127	91	65	36	0.2	0.2	0.5	0.2	0.3	0.4	0.6
	13	697.2	0.2%	119	107	92	77	61	49	36	0.4	0.4	0.2	0.2	0.2	0.3	0.4
2	2	732.3	0.8%	70	58	53	46	39	32	22	0.3	0.2	0.2	0.2	0.3	0.2	0.8
	5	716.1	0.8%	521	406	259	154	90	59	39	0.9	0.3	0.2	0.8	0.3	0.8	0.2
	8	708.9	0.5%	240	209	170	127	92	64	33	0.3	0.4	0.3	0.4	0.6	0.7	0.3
	13	684.7	0.3%	114	106	90	76	60	47	31	0.4	0.8	0.3	0.5	0.6	0.5	0.5

D.4 Machine 10

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	714.4	0.2%	74	62	55	48	42	33	23	0.3	0.3	0.3	0.4	0.3	0.2	0.3
	5	680.1	0.3%	514	413	265	152	87	50	34	1.5	1.8	1.0	0.9	1.1	**3.2**	0.2
	8	702.8	0.3%	255	222	177	131	95	67	34	0.7	0.5	0.4	0.4	0.3	0.6	0.1
	13	697.2	0.7%	126	113	96	80	64	49	33	0.8	0.7	0.6	0.7	0.5	0.4	0.3
2	2	712.9	0.4%	74	62	55	48	41	33	23	0.2	0.2	0.2	0.2	0.3	0.2	0.3
	5	684.4	0.3%	549	427	266	152	89	52	34	1.3	1.5	0.9	0.5	0.5	0.3	0.4
	8	694.9	0.3%	256	225	179	132	96	66	34	1.2	1.2	0.7	0.8	0.5	0.3	0.2
	13	706.0	0.4%	128	114	98	80	65	51	34	0.6	0.3	0.3	0.2	0.2	0.2	0.2

D.5 Machine 11

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	775.0	0.1%	79	65	58	50	43	36	24	0.3	0.5	0.3	0.2	0.3	0.3	0.5
	5	752.4	0.2%	562	436	270	157	91	56	35	1.2	1.0	0.6	0.4	0.2	0.2	0.1
	8	765.8	0.2%	268	233	185	138	100	69	36	0.5	0.4	0.3	0.2	0.2	0.2	0.4
	13	772.8	0.2%	129	113	98	82	67	54	34	0.3	0.5	0.2	0.4	0.3	0.2	0.6
2	*2*	***779.7***	*0.1%*	*78*	*66*	*56*	*50*	*43*	*36*	*24*	*0.4*	*0.4*	*0.5*	*0.4*	*0.5*	*0.4*	*0.5*
	5	*754.8*	*0.1%*	*555*	*435*	*271*	*158*	*91*	*55*	*36*	*1.1*	*0.8*	*0.6*	*0.5*	*0.2*	*0.2*	*0.4*
	8	*766.8*	*0.1%*	*267*	*233*	*183*	*137*	*99*	*69*	*36*	*0.4*	*0.2*	*0.2*	*0.3*	*0.2*	*0.3*	*0.2*
	13	*772.0*	*0.2%*	*132*	*116*	*101*	*83*	*69*	*56*	*39*	*0.4*	*0.4*	*0.2*	*0.3*	*0.2*	*0.1*	*0.1*
3	2	711.8	0.1%	78	66	58	51	43	36	24	0.2	0.2	0.1	0.2	0.2	0.1	0.2
	5	691.0	0.2%	561	440	271	158	90	54	34	0.7	0.6	0.3	0.2	0.4	0.1	0.3
	8	702.7	0.2%	267	234	185	138	100	70	36	0.2	0.2	0.2	0.2	0.2	0.1	0.2
	13	707.1	0.1%	129	116	99	82	67	53	33	0.2	0.2	0.5	0.2	0.2	0.2	0.4

D.6 Machine 13

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	*2*	*707.3*	*0.4%*	*68*	*57*	*50*	*44*	*37*	*32*	*22*	*0.8*	*0.4*	*0.6*	*0.3*	*0.4*	*0.3*	*0.3*
	5	*679.7*	*0.9%*	*527*	*405*	*260*	*157*	*89*	*61*	*43*	*3.1*	*2.7*	*1.6*	*1.2*	*1.1*	*0.4*	*0.2*
	8	*698.6*	*0.4%*	*237*	*207*	*166*	*126*	*90*	*65*	*33*	*0.9*	*0.9*	*0.7*	*0.5*	*0.7*	*0.5*	*0.5*
	13	*701.9*	*0.4%*	*111*	*99*	*85*	*72*	*57*	*48*	*32*	*0.7*	*1.1*	*0.5*	*0.7*	*0.3*	*1.3*	*0.5*
2	*2*	*703.2*	*0.8%*	*69*	*57*	*50*	*45*	*38*	*33*	*21*	*0.8*	*0.4*	*0.4*	*0.5*	*0.5*	*0.4*	*0.3*
	5	*690.3*	*0.7%*	*530*	*403*	*259*	*156*	*90*	*60*	*39*	*1.7*	*1.5*	*1.1*	*0.6*	*0.4*	*0.3*	*0.4*
	8	*697.7*	*0.6%*	*239*	*209*	*167*	*126*	*89*	*67*	*36*	*1.2*	*0.9*	*0.9*	*0.7*	*0.8*	*0.6*	*0.6*
	13	*712.5*	*0.6%*	*111*	*100*	*85*	*71*	*58*	*43*	*35*	*0.8*	*0.5*	*0.6*	*0.9*	*2.0*	*0.5*	*1.5*
3	2	681.8	1.0%	69	57	51	45	37	32	22	0.9	0.6	0.6	0.4	0.7	0.4	0.4
	5	659.4	0.3%	545	410	260	157	87	56	29	2.1	1.6	0.8	0.3	0.5	0.7	0.5
	8	674.3	0.3%	245	211	168	127	93	64	35	1.0	0.4	0.4	0.5	1.6	0.4	1.0
	13	668.8	0.8%	113	101	86	73	56	45	30	0.9	0.6	0.6	0.6	0.4	0.4	0.4
4	2	677.4	0.4%	69	57	51	46	39	33	23	0.6	0.3	0.4	0.6	0.6	0.6	0.4
	5	657.1	0.4%	536	411	262	158	88	59	35	2.0	2.0	1.1	0.9	0.8	1.0	0.5
	8	666.4	0.3%	247	213	170	128	95	66	32	0.6	0.4	0.6	0.5	0.7	0.4	0.6
	13	670.5	0.4%	115	101	87	72	60	44	32	0.7	0.5	0.5	0.6	0.5	0.7	0.4

D.7 Machine 15

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	763.0	0.2%	80	67	56	51	43	36	27	0.1	0.3	0.2	0.2	0.2	0.1	1.2
	5	743.0	0.1%	557	437	260	155	86	50	34	0.7	0.9	1.2	0.9	0.6	0.8	5.4
	8	754.8	0.2%	265	231	181	135	95	67	37	1.1	0.8	0.5	0.4	0.4	0.7	0.9
	13	761.2	0.2%	125	115	97	80	65	51	32	0.5	1.5	0.9	0.5	0.3	0.3	0.3
2	2	761.8	0.1%	78	69	58	53	46	35	27	0.3	0.2	0.1	0.2	0.3	0.2	0.6
	5	742.8	0.1%	547	432	267	154	88	49	31	0.7	0.6	1.0	0.6	1.8	0.7	0.4
	8	752.4	0.2%	265	238	177	138	99	64	38	0.4	0.4	0.5	0.2	0.2	0.3	0.7
	13	763.5	0.2%	129	116	99	81	66	51	32	0.3	0.2	0.3	0.2	0.4	0.3	0.6

D.8 Machine 16

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	728.1	0.2%	79	63	56	50	43	35	24	0.3	0.2	0.2	0.2	0.4	0.2	0.5
	5	710.6	0.1%	546	417	260	155	90	54	33	1.2	0.6	0.5	0.4	0.3	0.3	0.5
	8	718.6	0.3%	263	225	179	134	97	67	36	0.3	0.3	0.3	0.2	0.2	0.2	0.8
	13	723.6	0.3%	133	115	98	82	67	53	39	0.2	0.3	0.3	0.2	0.3	0.4	0.6
2	2	732.8	0.2%	79	63	56	49	42	35	24	0.3	0.1	0.1	0.1	0.2	0.1	0.2
	5	713.6	0.3%	530	406	256	152	88	51	35	0.8	0.5	0.3	0.2	0.2	0.3	0.2
	8	723.9	0.1%	259	226	178	134	97	67	37	0.2	0.2	0.2	0.2	0.1	0.2	0.4
	13	724.5	0.3%	134	119	102	85	69	55	38	0.3	0.1	0.1	0.2	0.3	0.3	0.1

D.9 Machine 28

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	776.4	0.2%	75	65	59	49	42	34	23	1.1	0.2	1.0	0.1	0.1	0.2	0.3
	5	756.8	0.2%	538	425	262	154	86	51	33	1.2	1.1	0.6	0.4	0.2	0.2	0.2
	8	769.5	0.2%	260	229	183	137	97	69	35	0.3	0.4	0.4	0.2	0.2	0.2	0.1
	13	769.1	0.1%	132	119	102	85	69	55	37	0.4	0.2	0.2	0.2	0.2	0.2	0.3
2	*2*	***777.7***	*0.3%*	*74*	*64*	*57*	*50*	*42*	*36*	*24*	*0.2*	*0.4*	*0.3*	*0.3*	*0.5*	*0.1*	*0.2*
	5	*758.5*	*0.1%*	*545*	*428*	*263*	*156*	*88*	*53*	*35*	*1.1*	*0.8*	*0.5*	*0.3*	*0.2*	*0.2*	*0.2*
	8	*770.8*	*0.2%*	*260*	*231*	*183*	*136*	*97*	*68*	*35*	*0.4*	*0.4*	*0.7*	*0.3*	*0.4*	*0.2*	*0.1*
	13	*775.8*	*0.1%*	*131*	*119*	*101*	*83*	*67*	*54*	*36*	*0.2*	*0.7*	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*
3	2	713.8	0.1%	74	65	58	48	43	36	24	0.3	0.4	0.7	0.9	0.3	0.4	0.1
	5	694.6	0.1%	541	428	262	157	89	51	33	1.4	0.5	0.6	0.3	0.3	0.3	0.2
	8	704.3	0.2%	260	241	178	133	95	66	35	0.4	2.6	0.4	0.7	0.7	0.4	0.2
	13	715.1	0.2%	126	117	98	82	66	52	33	0.2	0.6	0.1	0.1	0.1	0.2	0.1

D.10 Machine 30

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	697.9	0.2%	76	63	56	49	43	36	26	0.5	0.2	0.1	0.1	0.2	0.1	0.4
	5	681.2	0.1%	543	430	266	156	90	55	38	1.1	0.7	0.6	0.4	0.1	0.1	0.7
	8	690.0	0.3%	259	224	179	134	97	68	39	1.4	0.9	0.4	0.3	0.4	0.4	0.3
	13	694.5	0.2%	124	112	96	80	65	52	36	0.5	0.5	0.5	0.3	0.6	1.0	0.2
2	2	701.4	0.2%	76	63	57	49	43	35	27	0.6	0.1	0.2	0.4	0.6	0.9	0.4
	5	684.7	0.1%	534	426	267	157	90	56	37	1.7	0.9	0.6	0.5	0.1	0.2	0.3
	8	694.0	0.2%	260	224	179	133	96	68	37	0.4	0.4	0.2	0.3	0.3	0.2	0.4
	13	701.0	0.2%	126	111	99	81	68	56	38	0.4	0.5	0.1	0.1	0.3	0.6	0.2

D.11 Machine 32

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	717.2	0.4%	74	60	53	47	40	33	22	0.2	0.5	0.1	0.2	0.3	0.2	0.2
	5	714.0	0.4%	514	405	255	150	87	57	39	1.1	0.6	1.0	0.4	0.4	0.3	0.3
	8	702.7	0.3%	250	216	172	128	91	64	35	0.5	0.6	0.5	0.4	0.1	0.3	0.3
	13	702.5	0.3%	124	110	95	79	63	50	35	0.3	0.3	0.4	0.5	0.7	0.4	0.9
2	2	736.9	0.4%	72	60	53	46	39	33	22	0.8	0.2	0.2	0.3	0.3	0.1	0.2
	5	730.0	0.5%	519	408	255	150	89	57	39	0.7	0.8	0.4	0.7	0.3	0.4	0.2
	8	717.1	0.5%	250	216	170	128	92	64	35	0.5	0.4	0.3	0.2	0.6	0.5	0.3
	13	698.4	0.5%	121	107	93	76	61	49	35	0.6	0.5	0.2	0.3	0.1	0.2	0.2

D.12 Machine 33

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	*2*	*729.7*	*0.2%*	*71*	*58*	*51*	*45*	*39*	*32*	*22*	*0.3*	*0.6*	*0.5*	*0.1*	*0.3*	*0.2*	*0.1*
	5	*727.4*	*0.2%*	*521*	*406*	*256*	*154*	*92*	*56*	*38*	*0.4*	*0.4*	*0.3*	*0.2*	*0.2*	*0.3*	*0.2*
	8	*721.2*	*0.2%*	*242*	*208*	*166*	*126*	*91*	*65*	*34*	*0.3*	*0.3*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*
	13	*741.2*	*0.4%*	*112*	*102*	*88*	*73*	*59*	*45*	*32*	*0.2*	*0.7*	*0.3*	*0.4*	*0.2*	*0.3*	*0.2*
2	*2*	*745.7*	*0.5%*	*67*	*56*	*50*	*44*	*38*	*31*	*21*	*0.3*	*0.3*	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*
	5	*730.1*	*1.1%*	*503*	*401*	*246*	*147*	*89*	*55*	*38*	*0.5*	*0.8*	*0.5*	*0.3*	*0.3*	*0.3*	*0.4*
	8	*725.8*	*0.1%*	*236*	*203*	*162*	*123*	*88*	*61*	*32*	*0.3*	*0.7*	*0.3*	*0.4*	*0.4*	*0.7*	*0.3*
	13	*748.8*	*0.2%*	*114*	*102*	*88*	*73*	*58*	*45*	*31*	*0.2*	*0.3*	*0.2*	*0.2*	*0.1*	*0.1*	*0.2*
3	2	683.2	0.2%	75	62	56	49	42	35	23	0.2	0.4	0.2	0.3	0.1	0.2	0.8
	5	660.0	0.2%	561	440	272	161	96	61	41	0.4	0.8	0.4	0.7	0.4	0.2	0.8
	8	667.8	0.1%	261	225	179	133	97	68	36	0.4	0.3	0.2	0.2	0.2	0.2	0.2
	13	688.3	0.5%	120	110	95	79	64	49	32	0.6	0.9	0.2	0.4	0.1	0.7	0.4
4	2	705.4	0.3%	74	62	55	48	42	34	22	0.5	0.3	0.1	0.1	0.2	0.1	0.5
	5	649.4	0.4%	568	450	276	166	96	63	39	0.4	0.8	0.3	0.6	1.1	0.6	0.4
	8	691.0	0.2%	259	224	179	135	97	68	36	0.6	0.8	0.3	0.5	0.5	0.2	0.5
	13	671.2	0.4%	130	117	100	83	67	52	33	0.4	0.7	0.3	0.5	0.1	0.3	0.6

D.13 Machine 34

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	2	704.4	0.4%	71	60	54	47	39	33	22	0.9	0.2	0.1	0.1	0.5	0.5	0.3
	5	700.3	0.2%	532	406	258	155	86	59	32	1.3	0.8	0.4	0.4	0.3	0.3	0.3
	8	696.0	0.2%	250	218	174	132	92	66	32	0.3	0.3	0.2	0.2	0.3	0.1	0.2
	13	687.2	0.3%	125	112	96	79	62	51	32	0.5	0.2	0.3	0.3	0.2	0.3	1.1
3	2	700.1	0.2%	72	59	53	46	39	33	21	0.7	0.3	0.1	1.5	0.9	0.7	0.4
	5	694.4	0.2%	552	403	255	152	83	54	34	0.3	0.4	0.3	0.3	0.2	0.2	0.3
	8	686.7	0.2%	251	219	173	131	91	66	32	0.2	0.2	0.5	0.2	0.4	0.6	0.4
	13	689.1	0.2%	123	111	97	80	64	52	31	0.2	0.3	0.3	0.3	0.2	0.4	0.3

D.14 Machine 38

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	709.1	0.7%	69	59	52	49	41	36	21	0.2	0.3	0.2	0.2	0.1	0.2	0.1
	5	704.3	1.0%	499	383	249	152	89	57	33	1.5	1.1	0.8	0.6	0.4	0.4	0.3
	8	705.6	0.6%	238	210	170	132	95	69	32	0.4	0.5	0.6	0.4	0.3	0.3	0.3
	13	683.5	1.0%	117	106	91	79	63	53	33	0.4	0.4	0.4	0.3	0.3	0.2	0.2
2	2	692.5	0.9%	69	59	53	49	41	36	21	0.2	0.1	0.1	0.1	0.2	0.1	0.1
	5	693.6	1.2%	511	389	251	151	90	58	33	0.7	0.4	0.3	0.1	0.1	0.1	0.2
	8	689.6	1.2%	238	209	169	131	95	69	32	0.4	0.3	0.3	0.5	0.2	0.1	0.3
	13	682.4	0.7%	118	106	92	79	64	53	33	0.2	0.2	0.1	0.2	0.2	0.2	0.2

D.15 Machine 39

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	689.2	0.1%	76	63	56	51	42	36	24	0.8	0.2	0.4	0.3	0.1	0.1	0.2
	5	668.0	0.2%	530	425	271	160	90	55	34	2.8	0.5	0.3	0.3	0.5	0.2	0.3
	8	678.1	0.2%	260	224	181	137	98	70	36	0.7	0.5	0.7	0.8	0.5	0.4	0.2
	13	691.9	0.2%	126	111	97	81	65	52	36	1.0	0.5	0.3	0.7	0.2	0.7	1.4
2	2	692.8	0.2%	76	62	56	50	42	35	24	1.0	0.2	0.3	0.3	0.8	0.1	0.2
	5	671.6	0.2%	548	435	276	160	90	55	34	1.5	0.7	0.2	0.3	0.4	0.1	0.2
	8	683.6	0.2%	257	226	181	138	98	70	36	0.9	0.5	0.2	0.4	0.2	0.2	0.2
	13	696.0	0.2%	127	112	97	83	64	51	37	0.9	0.3	0.2	0.7	0.1	0.3	0.8

D.16 Machine 40

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	706.8	0.1%	75	63	56	50	42	35	24	0.2	0.2	0.1	0.1	0.5	0.3	0.4
	5	707.2	0.2%	550	428	268	156	89	54	35	1.1	0.3	0.3	0.2	0.2	0.2	0.1
	8	706.9	0.1%	261	227	180	135	97	68	34	0.6	0.2	0.2	0.2	0.3	0.6	0.8
	13	706.8	0.1%	128	120	102	86	69	55	35	0.5	0.2	0.2	0.1	0.1	0.1	0.3
2	2	706.6	0.3%	76	63	56	50	42	35	24	0.2	0.2	0.2	0.0	0.4	0.5	0.5
	5	707.0	0.2%	569	417	263	155	88	55	35	0.9	0.3	0.4	0.3	0.2	0.2	0.5
	8	707.1	0.0%	262	228	180	136	97	68	35	0.3	0.5	0.2	0.1	0.1	0.3	0.2
	13	707.3	0.2%	132	118	102	88	71	54	40	0.7	0.6	0.4	0.3	0.2	0.5	0.3

D.17 Machine 45

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	716.2	0.3%	78	63	56	49	42	36	25	0.4	0.3	0.4	0.3	0.5	0.1	0.1
	5	717.8	0.2%	514	396	250	148	85	50	29	2.3	1.5	1.0	0.8	0.6	0.5	0.5
	8	709.5	0.4%	255	219	174	130	94	66	33	1.5	0.9	0.8	0.6	0.6	0.7	0.4
	13	703.3	0.2%	132	115	97	81	66	55	36	0.8	0.6	0.7	0.4	0.4	0.1	0.3
2	2	705.8	0.4%	79	64	56	50	43	36	25	0.5	0.5	0.5	0.3	0.2	0.1	0.1
	5	716.1	0.2%	523	400	254	149	86	49	28	1.8	1.5	0.9	0.7	0.6	0.4	0.5
	8	705.6	0.3%	257	223	177	132	96	68	33	1.0	1.0	0.9	0.7	0.5	0.6	0.6
	13	712.7	0.2%	127	112	95	79	64	54	35	0.5	0.5	0.7	0.5	0.1	0.1	0.4

D.18 Machine 47

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	697.5	0.1%	78	66	59	52	44	37	26	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	5	685.4	0.2%	570	415	257	151	85	51	31	0.6	0.6	0.1	0.1	0.3	0.2	0.2
	8	688.8	0.1%	268	235	187	139	100	70	36	0.3	0.2	0.1	0.1	0.3	0.1	0.3
	13	690.7	0.2%	129	116	98	82	66	53	34	0.2	0.2	0.2	0.2	0.3	0.2	0.6
2	2	699.5	0.1%	80	65	60	51	44	37	25	0.1	0.2	0.2	0.2	0.1	0.1	0.3
	5	684.6	0.1%	540	419	266	154	87	52	32	1.0	0.5	0.3	0.1	0.2	0.1	0.2
	8	688.3	0.2%	268	234	187	138	101	70	35	0.2	0.2	0.1	0.2	0.3	0.1	0.1
	13	689.2	0.1%	131	119	103	85	70	56	36	0.3	0.2	0.2	0.2	0.1	0.1	0.1

D.19 Machine 48

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	750.1	0.4%	71	60	53	47	40	34	22	0.3	0.1	0.1	0.1	0.1	0.1	0.1
	5	736.0	0.1%	545	407	256	150	87	55	34	0.9	0.6	0.3	0.3	0.3	0.3	0.4
	8	743.9	0.2%	249	214	171	128	92	65	34	1.1	0.2	0.1	0.1	0.1	0.1	0.1
	13	743.7	0.1%	121	107	92	76	62	51	32	0.2	0.1	0.1	0.2	0.2	0.5	0.2
2	2	752.3	0.1%	71	59	52	47	42	34	22	0.5	0.3	0.3	0.1	0.3	0.3	0.3
	5	736.0	0.3%	542	411	257	151	89	56	37	1.0	0.4	0.3	0.4	0.3	0.3	0.3
	8	741.4	0.3%	248	215	172	128	92	65	34	0.6	0.3	0.4	0.3	0.2	0.2	0.2
	13	745.2	0.2%	126	110	95	79	63	50	35	1.1	0.5	0.2	0.5	1.0	0.3	0.3

D.20 Machine 49

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	727.2	0.1%	73	60	54	47	40	33	22	0.1	0.2	0.2	0.2	0.1	0.2	0.3
	5	727.9	0.1%	539	394	248	143	86	52	35	0.4	0.3	0.2	0.3	0.1	0.5	0.1
	8	725.1	0.1%	248	216	171	128	92	66	33	0.3	0.2	0.3	0.2	0.2	0.3	0.3
	13	726.8	0.2%	123	111	96	79	65	51	35	0.2	0.1	0.2	0.1	0.2	0.2	0.2
4	2	733.9	0.1%	73	60	53	47	40	33	23	0.1	0.2	0.2	0.1	0.2	0.1	0.2
	5	729.8	0.1%	534	404	252	146	85	48	34	0.7	0.3	0.1	0.2	0.1	0.2	0.1
	8	728.1	0.2%	249	216	170	127	93	63	35	0.3	0.2	0.1	0.1	0.1	0.2	0.2
	13	723.0	0.1%	126	112	96	80	65	52	37	0.2	0.1	0.1	0.1	0.1	0.4	0.2

D.21 Machine 50

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	*2*	*715.7*	*0.5%*	*70*	*60*	*53*	*47*	*41*	*34*	*23*	*1.5*	*0.1*	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*
	5	*698.5*	*0.2%*	*527*	*411*	*256*	*151*	*90*	*54*	*34*	***7.6***	*1.0*	*0.5*	*0.3*	*0.4*	*0.2*	*0.3*
	8	*708.6*	*0.2%*	*248*	*215*	*170*	*128*	*94*	*65*	*35*	***6.9***	*0.3*	*0.3*	*0.3*	*0.4*	*0.2*	*0.3*
	13	*715.2*	*0.1%*	*117*	*107*	*91*	*76*	*63*	*50*	*34*	***2.7***	*0.2*	*0.1*	*0.1*	*0.3*	*0.2*	*0.2*
2	2	711.1	0.3%	72	60	54	47	42	33	23	**4.9**	0.4	0.5	0.1	0.4	0.2	0.1
	5	691.3	0.3%	521	418	256	154	92	55	35	2.6	1.4	0.9	0.5	0.3	0.2	0.3
	8	701.9	0.1%	245	216	171	128	94	66	34	**3.3**	0.4	0.3	0.3	0.2	0.3	0.3
	13	704.7	0.2%	124	108	92	76	63	50	35	1.9	0.3	0.3	0.2	0.2	0.1	0.3
3	2	689.9	0.3%	73	61	53	47	42	34	24	0.2	0.4	0.2	0.1	0.3	0.1	0.2
	5	670.8	0.2%	502	409	261	156	94	57	34	0.6	0.8	0.5	0.4	0.4	0.2	0.3
	8	680.5	0.3%	240	216	170	129	95	66	35	0.4	0.6	0.3	0.2	0.2	0.2	0.3
	13	682.5	0.2%	116	112	95	79	66	52	36	1.1	1.1	1.2	1.1	1.1	1.2	1.7

D.22 Machine 51

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	711.6	0.7%	71	65	57	51	43	35	23	0.4	0.2	0.3	0.3	0.3	0.7	0.2
	5	711.2	0.7%	527	408	254	154	88	51	31	1.8	1.0	0.6	0.5	0.3	0.4	0.3
	8	711.3	0.8%	253	226	175	134	97	66	33	0.8	0.7	0.5	0.3	0.4	0.7	0.2
	13	696.7	0.8%	126	117	98	82	66	51	33	0.5	0.2	0.3	0.1	0.2	0.4	0.2
2	2	720.2	0.5%	72	67	57	51	43	34	23	0.2	0.2	0.2	0.2	0.1	0.2	0.1
	5	721.4	0.9%	533	423	259	157	90	53	31	1.1	0.6	0.4	0.3	0.5	1.0	0.1
	8	713.9	0.8%	254	229	178	138	97	67	34	0.9	0.8	0.8	0.4	0.8	0.2	0.2
	13	713.4	0.9%	126	116	97	82	66	51	34	0.4	0.3	0.2	0.2	0.1	0.2	0.1

D.23 Machine 52

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	2	707.4	0.1%	74	63	57	50	42	35	24	0.3	0.2	0.2	0.2	0.2	0.2	0.3
	5	707.5	0.5%	558	417	258	149	86	52	35	0.9	0.4	0.3	0.3	0.2	0.6	0.1
	8	706.4	0.7%	256	223	177	132	95	67	34	0.5	0.2	0.1	0.2	0.7	0.4	0.5
	13	706.8	0.5%	130	116	100	83	67	54	36	0.9	0.4	0.2	0.3	0.1	0.1	0.1
2	2	712.5	0.1%	75	61	55	49	42	34	25	0.6	0.4	0.2	0.3	0.3	0.2	0.3
	5	702.8	0.1%	565	422	258	150	85	53	32	1.6	0.9	0.4	0.4	0.3	0.3	0.2
	8	708.2	0.1%	258	221	178	131	94	66	34	0.4	0.5	0.6	0.3	0.3	0.5	0.2
	13	710.2	0.1%	126	114	98	81	66	53	36	0.4	0.3	0.2	0.2	0.2	0.2	0.2

D.24 Machine 53

Lap	Station	Load		Mean of the normalised deflection(µm)							Standard deviation of the normalised deflections (µm)						
		Mean	SD	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
1	*2*	*671.8*	***10.9%***	*76*	*62*	*56*	*49*	*42*	*35*	*23*	*0.4*	*0.3*	*0.3*	*0.4*	*0.1*	*0.5*	*0.2*
	5	*658.2*	***10.7%***	*559*	*419*	*261*	*154*	*87*	*52*	*33*	*1.7*	*0.4*	*0.6*	*0.8*	*1.1*	*1.0*	*1.1*
	8	*661.0*	***10.8%***	*257*	*223*	*179*	*137*	*96*	*68*	*35*	*0.5*	*0.5*	*0.3*	*0.5*	*0.4*	*0.7*	*0.9*
	13	*664.4*	***10.8%***	*126*	*113*	*98*	*80*	*65*	*51*	*33*	*0.4*	*0.5*	*0.3*	*0.3*	*0.4*	*0.3*	*0.3*
2	2	689.3	0.2%	76	62	56	49	42	35	23	0.1	0.1	0.1	0.1	0.0	0.1	0.1
	5	672.8	0.2%	560	419	263	153	86	52	33	0.7	0.4	0.4	0.3	0.3	0.2	0.2
	8	678.2	0.1%	258	224	179	134	96	67	34	0.2	0.3	0.4	0.2	0.3	0.1	0.2
	13	678.8	0.4%	120	110	96	79	64	51	31	0.2	0.1	0.3	0.2	0.2	0.1	0.2
	2	693.5	0.2%	76	63	56	50	42	35	23	0.2	0.3	0.1	0.1	0.2	0.2	0.2
	5	674.3	0.3%	578	426	263	153	86	51	33	0.4	0.2	0.2	0.3	0.2	0.2	0.2
	8	682.8	0.2%	263	226	180	134	96	66	34	0.4	0.6	0.2	0.6	0.4	0.3	0.1
	13	683.2	0.2%	123	109	95	78	64	50	30	0.2	0.2	0.3	0.6	0.3	0.4	0.3

Appendix E Reproducibility trial data

Note: In the tables below bold red text indicates that the value is outside of acceptable limits. Data from laps disregarded in the accreditation analysis are shown in grey italics (accept where the value is outside of acceptable limits).

Table E.1: All trial data during the main trial day (all laps - full dataset)

ID	Lap	Lap used	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)							
			D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean
2	*1*	*N*	*0.986*	*0.978*	*0.984*	*0.981*	*0.991*	*1.008*	*1.032*	*0.994*	*0.021*	*0.007*	*0.010*	*0.016*	*0.032*	*0.027*	*0.061*	*0.025*
	2	Y	0.984	0.980	0.981	0.985	0.998	1.009	1.018	0.994	0.045	0.012	0.014	0.017	0.026	0.024	0.046	0.026
	3	Y	0.974	0.979	0.983	0.990	1.000	1.016	1.029	0.996	0.050	0.017	0.014	0.014	0.020	0.021	0.050	0.027
	4	*N*	*0.993*	*0.981*	*0.982*	*0.985*	*0.996*	*0.998*	*0.995*	*0.990*	*0.035*	*0.014*	*0.014*	*0.016*	*0.013*	*0.026*	***0.072***	*0.027*
	5	*N*	*0.992*	*0.990*	*0.990*	*0.998*	*0.995*	*1.017*	*1.016*	*1.000*	***0.071***	*0.010*	*0.009*	*0.006*	*0.014*	*0.027*	*0.025*	*0.023*
	6	*N*	*1.020*	*0.994*	*0.996*	*1.000*	*1.004*	*1.009*	*1.014*	*1.005*	*0.041*	*0.008*	*0.008*	*0.008*	*0.014*	*0.011*	*0.031*	*0.017*
5	*1*	*N*	*1.041*	*1.035*	*1.037*	*1.036*	*1.029*	*1.033*	*1.048*	*1.037*	*0.013*	*0.009*	*0.011*	*0.015*	*0.023*	*0.030*	*0.041*	*0.020*
	2	Y	1.025	1.036	1.032	1.035	1.024	1.028	0.999	1.026	0.022	0.012	0.012	0.015	0.019	0.037	0.042	0.023
	3	Y	1.045	1.030	1.038	1.032	1.026	1.018	1.008	1.028	0.024	0.007	0.012	0.014	0.020	0.038	0.038	0.022
	4	*N*	*1.051*	*1.041*	*1.037*	*1.039*	*1.032*	*1.034*	*1.039*	*1.039*	*0.018*	*0.012*	*0.013*	*0.021*	*0.024*	*0.037*	*0.041*	*0.023*
6	*1*	*N*	*1.072*	*1.060*	*1.048*	*1.046*	*1.048*	*1.020*	*0.979*	*1.039*	*0.029*	*0.015*	*0.019*	*0.024*	*0.037*	*0.026*	*0.049*	*0.028*
	2	Y	1.056	1.068	1.047	1.046	1.052	1.030	0.992	1.041	0.021	0.016	0.013	0.021	0.030	0.033	0.059	0.028
	3	Y	1.059	1.065	1.057	1.052	1.055	1.034	1.025	1.050	0.036	0.019	0.024	0.029	0.039	0.045	**0.072**	0.038
	4	*N*	*1.063*	*1.064*	*1.049*	*1.041*	*1.052*	*1.035*	*1.026*	*1.047*	*0.023*	*0.015*	*0.017*	*0.024*	*0.030*	*0.045*	***0.095***	*0.036*
10	*1*	*N*	*0.999*	*0.993*	*0.990*	*1.005*	*0.999*	*1.015*	*1.019*	*1.003*	*0.013*	*0.006*	*0.005*	*0.009*	*0.010*	*0.010*	*0.036*	*0.013*
	2	Y	1.006	0.995	0.989	1.009	0.992	1.017	1.014	1.003	0.022	0.008	0.007	0.010	0.011	0.015	0.022	0.014
	3	Y	1.011	0.989	0.992	1.006	0.997	1.014	1.014	1.003	0.014	0.009	0.010	0.009	0.010	0.013	0.016	0.012
	4	*N*	*1.010*	*0.994*	*0.993*	*1.009*	*1.001*	*1.027*	*1.017*	*1.007*	*0.016*	*0.006*	*0.009*	*0.010*	*0.008*	*0.020*	*0.019*	*0.012*

ID	Lap	Lap used	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)							
			D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean
11	1	N	0.945	0.959	0.966	0.971	0.961	0.962	0.968	0.962	0.023	0.006	0.009	0.006	0.013	0.009	0.025	0.013
	2	Y	0.941	0.954	0.962	0.960	0.956	0.962	0.970	0.958	0.031	0.014	0.011	0.021	0.011	0.016	0.021	0.018
	3	Y	0.943	0.953	0.964	0.968	0.959	0.961	0.969	0.960	0.018	0.009	0.007	0.009	0.006	0.013	0.022	0.012
	4	N	0.950	0.950	0.957	0.965	0.959	0.967	0.963	0.959	0.012	0.009	0.011	0.008	0.014	0.017	0.032	0.015
	5	N	0.960	0.955	0.962	0.968	0.955	0.963	0.974	0.963	0.017	0.015	0.014	0.019	0.011	0.019	0.020	0.016
	6	N	0.949	0.960	0.971	0.972	0.966	0.979	0.954	0.965	0.025	0.014	0.012	0.016	0.013	0.010	0.032	0.017
13	1	N	1.054	1.070	1.062	1.053	1.055	1.031	0.973	1.043	0.022	0.027	0.033	0.036	0.036	0.059	**0.083**	0.042
	2	N	1.054	1.072	1.064	1.055	1.060	1.029	0.993	1.047	0.027	0.029	0.035	0.045	0.055	**0.082**	0.064	0.048
	3	N	1.056	1.070	1.066	1.050	1.070	1.026	0.978	1.045	0.032	0.030	0.035	0.047	0.044	**0.079**	**0.078**	0.049
	4	N	1.060	1.070	1.063	1.050	1.059	1.015	0.993	1.044	0.026	0.022	0.031	0.041	0.042	0.058	**0.086**	0.044
	5	N	1.076	1.081	1.074	1.067	1.051	1.048	1.038	**1.062**	0.030	0.024	0.036	0.045	0.051	**0.077**	**0.078**	0.049
	6	Y	1.070	1.081	1.072	1.066	1.058	1.051	1.048	**1.064**	0.028	0.029	0.037	0.049	0.050	0.062	0.047	0.043
	7	Y	1.076	1.085	1.075	1.066	1.041	1.052	1.044	**1.063**	0.042	0.030	0.042	0.049	0.060	**0.081**	**0.074**	**0.054**
15	1	N	0.947	0.930	0.955	0.962	0.949	1.002	0.983	0.961	0.041	0.034	0.030	0.026	0.035	0.056	0.063	0.041
	2	Y	0.945	0.942	0.958	0.961	0.963	0.994	0.933	0.957	0.052	0.039	0.030	0.037	0.050	0.048	0.046	0.043
	3	N	0.960	0.940	0.970	0.969	0.970	1.021	0.980	0.973	0.038	0.029	0.025	0.022	0.032	0.066	**0.104**	0.045
	4	Y	0.951	0.955	0.960	0.975	0.970	0.999	0.982	0.970	0.025	0.017	0.037	0.022	0.030	0.044	0.067	0.035
	5	N	0.963	0.959	0.975	0.972	0.971	1.019	0.973	0.976	0.034	0.018	0.023	0.040	0.043	0.058	0.069	0.041
	6	N	0.971	0.967	0.980	0.985	0.981	1.017	0.985	0.984	0.045	0.029	0.020	0.021	0.025	0.052	0.039	0.033
16	1	N	0.965	0.981	0.986	0.990	0.985	0.998	0.961	0.981	0.024	0.012	0.010	0.011	0.014	0.017	0.022	0.016
	2	Y	0.964	0.987	0.986	0.992	0.984	0.997	0.975	0.984	0.014	0.009	0.012	0.012	0.012	0.018	0.025	0.015
	3	Y	0.971	0.976	0.986	0.985	0.982	0.993	0.956	0.978	0.040	0.016	0.017	0.018	0.020	0.024	0.042	0.025
	4	N	0.960	0.975	0.981	0.986	0.984	0.994	0.968	0.978	0.024	0.018	0.018	0.018	0.021	0.019	0.036	0.022
28	1	N	0.986	0.966	0.957	0.985	0.982	0.986	0.997	0.980	0.018	0.017	0.030	0.011	0.027	0.020	0.026	0.021
	2	Y	0.984	0.949	0.964	0.981	0.977	0.982	1.012	0.978	0.008	0.038	0.019	0.017	0.029	0.026	0.039	0.025
	3	Y	0.984	0.960	0.942	0.991	0.976	0.970	1.011	0.976	0.021	0.014	0.042	0.025	0.022	0.024	0.041	0.027
	4	N	0.986	0.963	0.960	0.993	0.990	0.983	1.003	0.983	0.013	0.033	0.048	0.025	0.023	0.030	0.017	0.027

ID	Lap	Lap used	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)							
			D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean
30	*1*	*N*	*0.974*	*0.989*	*0.988*	*0.995*	*0.988*	*0.978*	*0.905*	*0.974*	*0.024*	*0.010*	*0.015*	*0.008*	*0.013*	*0.013*	*0.025*	*0.015*
	2	Y	0.981	0.992	0.985	0.992	0.984	0.976	0.900	0.973	0.022	0.010	0.007	0.007	0.014	0.016	0.025	0.014
	3	Y	0.982	0.982	0.982	0.989	0.982	0.974	**0.896**	0.970	0.008	0.011	0.007	0.009	0.014	0.011	0.032	0.013
	4	*N*	*0.981*	*0.989*	*0.982*	*0.990*	*0.982*	*0.974*	***0.898***	*0.971*	*0.014*	*0.012*	*0.007*	*0.008*	*0.007*	*0.011*	*0.024*	*0.012*
32	*1*	*N*	*1.009*	*1.026*	*1.040*	*1.043*	*1.044*	*1.030*	*1.001*	*1.028*	*0.064*	*0.014*	*0.014*	*0.015*	*0.020*	*0.034*	***0.071***	*0.033*
	2	Y	1.007	1.028	1.028	1.033	1.032	1.029	0.998	1.022	0.027	0.012	0.010	0.010	0.014	0.032	0.065	0.024
	3	*N*	*1.025*	***1.334***	*1.032*	*1.032*	*1.035*	*1.021*	*0.999*	***1.068***	*0.027*	***0.208***	*0.013*	*0.017*	*0.020*	*0.034*	***0.078***	***0.057***
	4	Y	1.019	1.021	1.042	1.024	1.031	1.023	0.993	1.022	0.020	0.019	0.017	0.022	0.021	0.043	0.065	0.030
	5	*N*	*1.045*	*1.039*	*1.062*	*1.041*	*1.041*	*1.033*	*1.006*	*1.038*	*0.020*	*0.010*	*0.011*	*0.016*	*0.019*	*0.035*	***0.076***	*0.027*
	6	*N*	*1.035*	*1.034*	*1.050*	*1.037*	*1.036*	*1.038*	*0.997*	*1.032*	*0.017*	*0.015*	*0.019*	*0.019*	*0.027*	*0.031*	*0.064*	*0.027*
33	*1*	*N*	*1.078*	*1.080*	*1.081*	*1.074*	*1.065*	*1.067*	*1.041*	***1.070***	*0.032*	*0.021*	*0.022*	*0.024*	*0.035*	*0.047*	*0.062*	*0.035*
	2	*N*	*1.078*	*1.093*	*1.087*	*1.082*	*1.067*	*1.076*	*1.052*	***1.076***	*0.023*	*0.022*	*0.021*	*0.025*	*0.035*	*0.055*	*0.062*	*0.035*
	3	*N*	***1.106***	***1.107***	***1.107***	*1.097*	*1.082*	*1.100*	*1.066*	***1.095***	*0.026*	*0.023*	*0.025*	*0.033*	*0.048*	*0.043*	***0.077***	*0.039*
	4	*N*	*1.002*	*1.001*	*1.001*	*0.996*	*0.985*	*0.994*	*0.958*	*0.991*	*0.029*	*0.023*	*0.022*	*0.025*	*0.041*	*0.052*	***0.085***	*0.039*
	5	*N*	*1.024*	*1.022*	*1.019*	*1.013*	*0.989*	*0.995*	*0.968*	*1.004*	*0.023*	*0.021*	*0.027*	*0.033*	*0.051*	*0.060*	***0.106***	*0.046*
	6	Y	1.025	1.020	1.016	1.012	0.991	1.010	0.966	1.006	0.023	0.024	0.027	0.033	0.051	0.045	**0.080**	0.041
	7	Y	1.027	1.025	1.019	1.015	0.995	1.004	0.963	1.007	0.024	0.024	0.025	0.029	0.052	0.059	**0.085**	0.042
34	*1*	*N*	*1.029*	*1.031*	*1.031*	*1.027*	*1.051*	*1.024*	*1.081*	*1.039*	*0.023*	*0.014*	*0.014*	*0.020*	*0.018*	*0.044*	*0.042*	*0.025*
	2	Y	1.035	1.031	1.024	1.025	1.052	1.033	1.089	1.041	0.018	0.010	0.012	0.018	0.019	0.021	0.026	0.018
	3	Y	1.038	1.027	1.030	1.024	1.048	1.019	1.075	1.037	0.018	0.009	0.012	0.015	0.016	0.035	0.023	0.018
	4	*N*	*1.032*	*1.030*	*1.028*	*1.026*	*1.051*	*1.024*	*1.078*	*1.038*	*0.026*	*0.013*	*0.015*	*0.020*	*0.023*	*0.034*	*0.025*	*0.022*
	5	*N*	*1.048*	*1.047*	*1.039*	*1.034*	*1.059*	*1.024*	*1.081*	*1.047*	*0.039*	*0.013*	*0.011*	*0.019*	*0.017*	*0.025*	*0.031*	*0.022*
	6	*N*	*1.039*	*1.042*	*1.037*	*1.032*	*1.054*	*1.030*	*1.061*	*1.042*	*0.035*	*0.013*	*0.015*	*0.023*	*0.024*	*0.027*	*0.031*	*0.024*
38	*1*	*N*	*1.075*	*1.057*	*1.042*	*1.002*	*1.007*	*0.968*	*1.081*	*1.033*	*0.011*	*0.011*	*0.009*	*0.011*	*0.013*	*0.012*	*0.020*	*0.012*
	2	Y	1.079	1.067	1.048	1.009	1.004	0.965	1.070	1.035	0.028	0.010	0.009	0.015	0.014	0.022	0.013	0.016
	3	Y	1.081	1.057	1.047	1.004	1.002	0.961	1.074	1.032	0.012	0.009	0.008	0.010	0.015	0.015	0.016	0.012
	4	*N*	*1.091*	*1.067*	*1.054*	*1.014*	*1.009*	*0.972*	*1.083*	*1.042*	*0.021*	*0.009*	*0.012*	*0.013*	*0.020*	*0.027*	*0.018*	*0.017*

ID	Lap	Lap used	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)							
			D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean
39	1	N	0.989	0.993	0.983	0.972	0.967	0.975	0.966	0.978	0.024	0.013	0.011	0.020	0.035	0.012	0.033	0.021
	2	Y	0.981	0.990	0.973	0.965	0.967	0.963	0.965	0.972	0.031	0.014	0.011	0.016	0.028	0.028	0.033	0.023
	3	Y	0.987	0.990	0.983	0.972	0.973	0.963	0.973	0.977	0.023	0.007	0.009	0.011	0.015	0.016	0.024	0.015
	4	N	**0.892**	0.998	0.985	0.978	0.977	0.981	0.971	0.969	**0.350**	0.013	0.010	0.010	0.011	0.009	0.024	**0.061**
	5	N	0.999	1.008	0.996	0.989	0.984	0.979	0.985	0.991	0.018	0.012	0.015	0.017	0.031	0.026	0.031	0.022
	6	N	0.993	1.005	0.986	0.986	0.981	0.985	0.982	0.988	0.020	0.012	0.013	0.009	0.009	0.013	0.032	0.016
40	1	N	0.972	0.978	0.983	0.980	0.988	0.989	1.002	0.985	0.015	0.008	0.008	0.010	0.009	0.012	0.017	0.011
	2	Y	0.973	0.981	0.980	0.979	0.986	0.988	1.004	0.985	0.020	0.010	0.010	0.011	0.014	0.017	0.022	0.015
	3	Y	0.977	0.976	0.984	0.975	0.985	0.978	0.990	0.981	0.021	0.013	0.013	0.016	0.016	0.021	0.019	0.017
	4	N	0.977	0.978	0.984	0.974	0.983	0.989	1.002	0.984	0.018	0.012	0.008	0.013	0.017	0.021	0.021	0.016
45	1	N	0.980	1.003	1.008	1.002	1.000	1.002	1.055	1.007	0.045	0.026	0.022	0.024	0.023	0.032	0.069	0.035
	2	Y	0.999	1.018	1.016	1.013	1.010	1.007	1.059	1.017	0.045	0.022	0.020	0.024	0.023	0.030	**0.079**	0.035
	3	Y	0.993	1.010	1.018	1.014	1.007	1.004	1.050	1.014	0.029	0.020	0.017	0.018	0.020	0.028	**0.071**	0.029
	4	N	0.996	1.016	1.017	1.017	1.015	1.008	1.052	1.017	0.035	0.025	0.021	0.021	0.022	0.030	0.065	0.031
47	1	N	0.959	0.954	0.953	0.960	0.957	0.962	0.963	0.958	0.023	0.017	0.022	0.024	0.030	0.039	0.050	0.029
	2	Y	0.954	0.960	0.955	0.965	0.963	0.967	0.993	0.965	0.017	0.016	0.017	0.022	0.029	0.033	0.054	0.027
	3	Y	0.958	0.953	0.955	0.965	0.959	0.964	0.984	0.963	0.015	0.014	0.018	0.018	0.022	0.033	0.049	0.024
	4	N	0.962	0.963	0.960	0.970	0.967	0.983	1.002	0.972	0.011	0.019	0.015	0.022	0.026	0.052	**0.073**	0.031
48	1	N	0.979	0.990	0.988	0.997	0.990	0.997	1.020	0.994	0.016	0.013	0.016	0.018	0.027	0.033	0.039	0.023
	2	Y	0.975	0.987	0.985	0.994	0.993	1.003	1.022	0.994	0.016	0.024	0.017	0.019	0.027	0.033	0.036	0.024
	3	Y	0.969	0.982	0.990	0.996	0.993	1.000	1.028	0.994	0.017	0.024	0.014	0.018	0.030	0.032	0.041	0.025
	4	N	0.970	0.990	0.988	0.995	0.996	1.006	1.020	0.995	0.018	0.013	0.015	0.019	0.024	0.031	0.035	0.022
49	1	N	1.031	1.033	1.033	1.051	1.032	1.053	1.024	1.037	0.012	0.008	0.007	0.008	0.009	0.018	0.042	0.015
	2	Y	1.039	1.036	1.036	1.051	1.035	1.055	1.033	1.041	0.014	0.007	0.008	0.006	0.013	0.013	0.024	0.012
	3	Y	1.024	1.030	1.039	1.046	1.039	1.050	1.032	1.037	0.017	0.009	0.008	0.013	0.013	0.017	0.033	0.016
	4	N	1.028	1.028	1.032	1.042	1.032	1.050	1.023	1.033	0.027	0.019	0.015	0.020	0.020	0.021	0.034	0.022

ID	Lap	Lap used	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)							
			D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean
50	*1*	*N*	*1.027*	*0.991*	*1.001*	*0.998*	*0.974*	*0.986*	*0.970*	*0.993*	*0.052*	*0.014*	*0.017*	*0.014*	*0.017*	*0.014*	*0.018*	*0.021*
	2	Y	1.023	0.989	0.999	0.998	0.968	0.985	0.966	0.990	0.029	0.013	0.013	0.012	0.014	0.020	0.021	0.017
	3	Y	0.987	0.994	0.992	0.994	0.992	1.003	1.012	0.996	0.018	0.010	0.007	0.010	0.009	0.018	0.018	0.013
	4	*N*	*1.015*	*0.987*	*0.998*	*0.994*	*0.969*	*0.984*	*0.966*	*0.988*	*0.045*	*0.010*	*0.013*	*0.010*	*0.013*	*0.012*	*0.023*	*0.018*
51	*1*	*N*	*1.008*	*0.972*	*0.989*	*0.974*	*0.970*	*1.009*	*1.027*	*0.993*	*0.022*	*0.031*	*0.021*	*0.015*	*0.018*	*0.020*	*0.044*	*0.025*
	2	Y	1.027	0.975	0.989	0.977	0.971	1.013	1.013	0.995	0.021	0.027	0.017	0.015	0.015	0.020	0.037	0.022
	3	Y	1.019	0.969	0.990	0.971	0.973	1.000	1.014	0.991	0.022	0.019	0.015	0.008	0.019	0.010	0.030	0.018
	4	*N*	*1.015*	*0.967*	*0.986*	*0.969*	*0.970*	*1.014*	*1.012*	*0.991*	*0.037*	*0.020*	*0.016*	*0.009*	*0.009*	*0.014*	*0.029*	*0.019*
52	*1*	*N*	*0.984*	*0.999*	*1.001*	*1.012*	*1.007*	*1.004*	*1.025*	*1.005*	*0.021*	*0.012*	*0.015*	*0.017*	*0.019*	*0.016*	*0.025*	*0.018*
	2	Y	0.995	1.001	0.995	1.008	1.000	1.008	1.019	1.004	0.008	0.006	0.013	0.013	0.016	0.012	0.022	0.013
	3	Y	0.991	0.992	0.997	1.002	1.002	1.001	1.019	1.001	0.017	0.008	0.008	0.010	0.012	0.017	0.021	0.013
	4	*N*	*0.991*	*0.994*	*0.995*	*1.003*	*1.004*	*1.010*	*1.023*	*1.003*	*0.015*	*0.010*	*0.010*	*0.014*	*0.014*	*0.013*	*0.021*	*0.014*
53	*1*	*N*	*0.988*	*0.997*	*0.992*	*0.988*	*0.995*	*1.003*	*1.020*	*0.997*	*0.010*	*0.009*	*0.008*	*0.007*	*0.006*	*0.011*	*0.018*	*0.010*
	2	Y	0.979	1.000	0.989	0.989	0.992	0.998	1.017	0.995	0.015	0.008	0.008	0.010	0.016	0.016	0.020	0.013
	3	Y	0.987	0.994	0.992	0.994	0.992	1.003	1.012	0.996	0.018	0.010	0.007	0.010	0.009	0.018	0.018	0.013
	4	*N*	*0.982*	*0.998*	*0.989*	*0.984*	*0.993*	*0.998*	*1.014*	*0.994*	*0.023*	*0.017*	*0.012*	*0.025*	*0.017*	*0.024*	*0.017*	*0.019*

Table E.2: All trial data during the main trial day (analysed laps – single data point removed where appropriate)

ID	Lap	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)								Excluded Geophone and test station
		D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean	
2	2	0.984	0.980	0.981	0.985	0.998	1.009	1.018	0.994	0.045	0.012	0.014	0.017	0.026	0.024	0.046	0.026	
	3	0.974	0.979	0.983	0.990	1.000	1.016	1.029	0.996	0.050	0.017	0.014	0.014	0.020	0.021	0.050	0.027	
5	2	1.025	1.036	1.032	1.035	1.024	1.028	0.999	1.026	0.022	0.012	0.012	0.015	0.019	0.037	0.042	0.023	
	3	1.045	1.030	1.038	1.032	1.026	1.018	1.008	1.028	0.024	0.007	0.012	0.014	0.020	0.038	0.038	0.022	
6	2	1.056	1.068	1.047	1.046	1.052	1.030	0.992	1.041	0.021	0.016	0.013	0.021	0.030	0.033	0.059	0.028	
	3	1.059	1.065	1.057	1.052	1.055	1.034	1.025	1.050	0.036	0.019	0.024	0.029	0.039	0.045	0.059	0.036	Station 5 D7
10	2	1.006	0.995	0.989	1.009	0.992	1.017	1.014	1.003	0.022	0.008	0.007	0.010	0.011	0.015	0.022	0.014	
	3	1.011	0.989	0.992	1.006	0.997	1.014	1.014	1.003	0.014	0.009	0.010	0.009	0.010	0.013	0.016	0.012	
11	2	0.941	0.954	0.962	0.960	0.956	0.962	0.970	0.958	0.031	0.014	0.011	0.021	0.011	0.016	0.021	0.018	
	3	0.943	0.953	0.964	0.968	0.959	0.961	0.969	0.960	0.018	0.009	0.007	0.009	0.006	0.013	0.022	0.012	
13	6	1.070	1.081	1.072	1.059	1.058	1.051	1.048	1.063	0.028	0.029	0.037	0.049	0.050	0.062	0.047	0.043	Station 10 D4
	7	1.076	1.085	1.075	1.066	1.041	1.052	1.030	1.061	0.042	0.030	0.042	0.049	0.060	0.081	0.066	0.053	Station 10 D7
15	2	0.945	0.942	0.958	0.961	0.963	0.994	0.933	0.957	0.052	0.039	0.030	0.037	0.050	0.048	0.046	0.043	
	4	0.951	0.955	0.960	0.975	0.970	0.999	0.982	0.970	0.025	0.017	0.037	0.022	0.030	0.044	0.067	0.035	
16	2	0.964	0.987	0.986	0.992	0.984	0.997	0.975	0.984	0.014	0.009	0.012	0.012	0.012	0.018	0.025	0.015	
	3	0.971	0.976	0.986	0.985	0.982	0.993	0.956	0.978	0.040	0.016	0.017	0.018	0.020	0.024	0.042	0.025	
28	2	0.984	0.949	0.964	0.981	0.977	0.982	1.012	0.978	0.008	0.038	0.019	0.017	0.029	0.026	0.039	0.025	
	3	0.984	0.960	0.942	0.991	0.976	0.970	1.011	0.976	0.021	0.014	0.042	0.025	0.022	0.024	0.041	0.027	
30	2	0.981	0.992	0.985	0.992	0.984	0.976	0.900	0.973	0.022	0.010	0.007	0.007	0.014	0.016	0.025	0.014	
	3	0.982	0.982	0.982	0.989	0.982	0.974	0.901	0.970	0.008	0.011	0.007	0.009	0.014	0.011	0.032	0.013	Station 3 D7
32	2	1.007	1.028	1.028	1.033	1.032	1.029	0.998	1.022	0.027	0.012	0.010	0.010	0.014	0.032	0.065	0.024	
	4	1.019	1.021	1.042	1.024	1.031	1.023	0.993	1.022	0.020	0.019	0.017	0.022	0.021	0.043	0.065	0.030	
33	6	1.025	1.020	1.016	1.012	0.991	1.010	0.966	1.006	0.023	0.024	0.027	0.033	0.051	0.045	0.070	0.039	Station 5 D7
	7	1.027	1.025	1.019	1.015	0.995	1.004	0.963	1.007	0.024	0.024	0.025	0.029	0.052	0.059	0.068	0.040	Station 5 D7
34	2	1.035	1.031	1.024	1.025	1.052	1.033	1.089	1.041	0.018	0.010	0.012	0.018	0.019	0.021	0.026	0.018	
	3	1.038	1.027	1.030	1.024	1.048	1.019	1.075	1.037	0.018	0.009	0.012	0.015	0.016	0.035	0.023	0.018	

ID	Lap	Field Calibration Factor (FCF)								Standard Deviation of Deviation Ratio (SDDR)								Excluded Geophone and test station
		D1	D2	D3	D4	D5	D6	D7	Mean	D1	D2	D3	D4	D5	D6	D7	Mean	
38	2	1.079	1.067	1.048	1.009	1.004	0.965	1.070	1.035	0.028	0.010	0.009	0.015	0.014	0.022	0.013	0.016	
	3	1.081	1.057	1.047	1.004	1.002	0.961	1.074	1.032	0.012	0.009	0.008	0.010	0.015	0.015	0.016	0.012	
39	2	0.981	0.990	0.973	0.965	0.967	0.963	0.965	0.972	0.031	0.014	0.011	0.016	0.028	0.028	0.033	0.023	
	3	0.987	0.990	0.983	0.972	0.973	0.963	0.973	0.977	0.023	0.007	0.009	0.011	0.015	0.016	0.024	0.015	
40	2	0.973	0.981	0.980	0.979	0.986	0.988	1.004	0.985	0.020	0.010	0.010	0.011	0.014	0.017	0.022	0.015	
	3	0.977	0.976	0.984	0.975	0.985	0.978	0.990	0.981	0.021	0.013	0.013	0.016	0.016	0.021	0.019	0.017	
45	2	0.999	1.018	1.016	1.013	1.010	1.007	1.059	1.017	0.045	0.022	0.020	0.024	0.023	0.030	0.066	0.033	Station 5 D7
	3	0.993	1.010	1.018	1.014	1.007	1.004	1.050	1.014	0.029	0.020	0.017	0.018	0.020	0.028	0.061	0.028	Station 5 D7
47	2	0.954	0.960	0.955	0.965	0.963	0.967	0.993	0.965	0.017	0.016	0.017	0.022	0.029	0.033	0.054	0.027	
	3	0.958	0.953	0.955	0.965	0.959	0.964	0.984	0.963	0.015	0.014	0.018	0.018	0.022	0.033	0.049	0.024	
48	2	0.975	0.987	0.985	0.994	0.993	1.003	1.022	0.994	0.016	0.024	0.017	0.019	0.027	0.033	0.036	0.024	
	3	0.969	0.982	0.990	0.996	0.993	1.000	1.028	0.994	0.017	0.024	0.014	0.018	0.030	0.032	0.041	0.025	
49	2	1.039	1.036	1.036	1.051	1.035	1.055	1.033	1.041	0.014	0.007	0.008	0.006	0.013	0.013	0.024	0.012	
	3	1.024	1.030	1.039	1.046	1.039	1.050	1.032	1.037	0.017	0.009	0.008	0.013	0.013	0.017	0.033	0.016	
50	2	1.023	0.989	0.999	0.998	0.968	0.985	0.966	0.990	0.029	0.013	0.013	0.012	0.014	0.020	0.021	0.017	
	3	0.987	0.994	0.992	0.994	0.992	1.003	1.012	0.996	0.018	0.010	0.007	0.010	0.009	0.018	0.018	0.013	
51	2	1.027	0.975	0.989	0.977	0.971	1.013	1.013	0.995	0.021	0.027	0.017	0.015	0.015	0.020	0.037	0.022	
	3	1.019	0.969	0.990	0.971	0.973	1.000	1.014	0.991	0.022	0.019	0.015	0.008	0.019	0.010	0.030	0.018	
52	2	0.995	1.001	0.995	1.008	1.000	1.008	1.019	1.004	0.008	0.006	0.013	0.013	0.016	0.012	0.022	0.013	
	3	0.991	0.992	0.997	1.002	1.002	1.001	1.019	1.001	0.017	0.008	0.008	0.010	0.012	0.017	0.021	0.013	
53	2	0.979	1.000	0.989	0.989	0.992	0.998	1.017	0.995	0.015	0.008	0.008	0.010	0.016	0.016	0.020	0.013	
	3	0.987	0.994	0.992	0.994	0.992	1.003	1.012	0.996	0.018	0.010	0.007	0.010	0.009	0.018	0.018	0.013	

Appendix F Accreditation trial – Trial results

ID	Make, model and serial number	Repeatability	Reproducibility				Elapsed distance	Temperature			OSGR (Horizontal)
			FCF Mean	FCF Individual	SDDR Mean	SDDR Individual		100mm	Surface	Air	
2	Dynatest FWD 8002 SN 102	Pass	Pass	Pass	Pass	Pass	Pass	Low	*No data*	*No data*	*No data*
5	Dynatest HWD 8082 SN 050	Pass	Pass	Pass	Pass	Pass	Pass	Low	*No data*	*No data*	High
6	Dynatest HWD 8082 SN 018	Pass	Pass	Pass	Pass	Pass	Pass	High	*No data*	Medium	High
10	Dynatest FWD 8002 SN 192	Pass	Pass	Pass	Pass	Pass	Pass	Low	*No data*	*No data*	Low
11	Dynatest FWD 8002 SN 187	Pass	Pass	Pass	Pass	Pass	Pass	High	*No data*	*No data*	*No data*
13	Dynatest HWD 8082 SN 029	Pass	Fail	Pass	Fail	Fail	Pass	Not Suitable	*No data*	*No data*	*No data*
15	Dynatest FWD 8002 SN 203	Pass	Pass	Pass	Pass	Pass	Pass	High	*No data*	*No data*	*No data*
16	Dynatest FWD 8002 SN 214	Pass	Pass	Pass	Pass	Pass	Pass	Medium	*No data*	*No data*	*No data*
28	Dynatest FWD 8002 SN 271	Pass	Pass	Pass	Pass	Pass	Pass	High	*No data*	*No data*	High
30	Dynatest FWD 8002 SN 173	Pass	Pass	Pass	Pass	Pass	Pass	High	*No data*	*No data*	Medium
32	Dynatest HWD 8082 SN 069	Pass	Pass	Pass	Pass	Pass	Pass	Medium	No data	High	*No data*
33	Dynatest HWD 8082 SN 070	Pass	Pass	Pass	Pass	Pass	Pass	High	*No data*	*No data*	*No data*
34	Dynatest HWD 8082 SN 108	Pass	Pass	Pass	Pass	Pass	Pass	Low	Low	Low	Not Suitable
38	Grontmij PRI 1500 1111-448	Pass	Pass	Pass	Pass	Pass	Pass	High	Low	Medium	Not Suitable
39	Dynatest FWD 8002 SN 388	Pass	Pass	Pass	Pass	Pass	Pass	Medium	Medium	Medium	High
40	Dynatest FWD 8012 SN 002	Pass	Pass	Pass	Pass	Pass	Pass	High	High	Medium	Medium
45	Grontmij Carlbro PRI2100 0903-088	Pass	Pass	Pass	Pass	Pass	Pass	High	Not Suitable	Not Suitable	*No data*
47	Dynatest FWD 8002 SN 452	Pass	Pass	Pass	Pass	Pass	Pass	High	Low	Medium	High
48	Dynatest FWD 8002 SN 424	Pass	Pass	Pass	Pass	Pass	Pass	High	High	High	*No data*
49	Dynatest HWD 8082 SN 146	Pass	Pass	Pass	Pass	Pass	Pass	Medium	*No data*	High	Medium
50	RINCENT HeavyDyn HVY-101A	Pass	Pass	Pass	Pass	Pass	Pass	High	Low	High	Medium
51	Grontmij FWD PRI2500 SN 0415-490	Pass	Pass	Pass	Pass	Pass	Pass	High	Low	Low	*No data*
52	Dynatest FFWD 8012 SN 057	Pass	Pass	Pass	Pass	Pass	Pass	Medium	High	Medium	*No data*
53	Dynatest FWD 8002 SN 098	Pass	Pass	Pass	Pass	Pass	Pass	Medium	Medium	*No data*	High

Highways England 2019 National Dynamic Plate Test device 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 Dynamic Plate test devices (FWD and HWD) supported by ongoing QA. In order to undertake accredited surveys, the survey devices are required to meet the mandatory criteria of the trial.

This report covers the 2019 trial run by TRL held on the Horiba-MIRA proving ground between the 24th and 25th of September 2019.

Other titles from this subject area

PPR1017	Highways England 2018 National Dynamic Plate Test device Accreditation Trial. S Brittain. 2022
PPR944	Highways England 2017 National Dynamic Plate Test device Accreditation Trial. S Brittain. 2020
PPR945	Highways England 2016 National Dynamic Plate Test device Accreditation Trial. S Brittain. 2020
PPR946	Highways England 2015 National Dynamic Plate Test device Accreditation Trial. S Brittain, M Militzer. 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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