THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR974

Highways England 2020 National Dynamic Plate Test Device Accreditation Trial

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Report details

Report prepared for:	Highways England		
Project/customer reference:	SPATS: 1-657		
Copyright:	© TRL Limited		
Report date:	11/03/2022		
Report status/version:	1.0		
Quality approval:			
Cathy Booth (Project Manager)	**Cathy Booth**	Dave Gershkoff (Technical Reviewer)	**Dave Gershkoff**

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Contents amendment record

This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Reviewer
1.0	11/03/2022	Converted to published report for historic continuity	SB	DG

Executive Summary

The 2020 UK Dynamic Plate Test (DPT) device accreditation trial was held on the Twin Straights on the Horiba-MIRA proving ground on the 22nd and 24th September 2020. This was the twenty-second 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 nineteen machines took part in the trial, consisting of:

- Eleven trailer-mounted Dynatest FWDs;
- Five trailer-mounted Dynatest HWDs ;
- Two trailer-mounted Grontmij FWDs; and
- One trailer-mounted Rincent HWD.

Due to the COVID-19 health situation it was necessary to amend the test process for the trial. Therefore, the trial followed a variation of the format to that which was used successfully in previous mandatory trials carried out since 1999. The 2020 trial took place over 3 days. The first day included checks on the geophone positions and initial testing of the devices. The second day was used to process the data and provide feedback on the results so that the owners of machines not meeting the criteria could investigate their devices. The assessments undertaken 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 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.

At the completion of the trial it was identified that:

- All nineteen machines met the mandatory criteria of the trial.

- 3-dimensional positional data was supplied by six of the test machines. This data was provided in lat/long/height format. After conversion of the data by TRL into the OSGR format, five machines achieved a high rating and one a medium 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 therefore consideration should be given to imposing the requirement of providing the data in OSGR format.
- All nineteen operators of the machines provided a full set of temperature measurements at depth. Four achieved a high rating, eight a medium rating and seven a low rating.
- Ten machines provided surface temperature measurements. One machine achieved a high rating, two a medium rating, three a low rating and four were identified as not suitable.
- Eleven machines provided air temperature measurements. One of these machines did not provide sufficient data for an assessment so the remaining ten were assessed. Although air temperature measurements from DPTs are not used in the contactless pavement temperature test method for DPTs set out in CS 229 (DMRB CS 229, 2020), it seemed prudent to review the data supplied. Applying the surface temperature criteria to the measurements, one machine achieved a high performance level, five were medium, four low and one was identified as not suitable.

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1 Introduction

Current advice on the use of Dynamic Plate Test devices, provided in CS229 (where they are referred to as FWDs) of the Design Manual for Roads and Bridges (DMRB CS 229, 2020), requires that all of these devices shall be operated in accordance with the Accreditation and Quality Assurance of Dynamic Plate Test Survey Devices document (TRL, 2020). This Accreditation and QA specification document outlines the Accreditation trial procedure that needs to be undertaken. This process forms part of a system to ensure that consistent, high quality data is obtained from condition surveys. 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.

The objectives of the 2020 DPT Accreditation trial were:

- To ensure that all measuring systems are in good mechanical order.
- 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-second mandatory UK DPT accreditation trial was held on the 22nd and 24th September 2020 on behalf of Highways England. Due to the COVID-19 health situation, it was necessary to amend the test process for the trial. Therefore, the trial followed a variation of the format that was used successfully in the previous mandatory trials carried out since 1999. The 2020 trial included the following mandatory checks:

- Reproducibility;
- Repeatability; and
- Distance measurement.

And the following non-mandatory checks

- 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 trials were 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 all subsequent trials have been held on the proving grounds at Horiba-MIRA. This report describes the conduct and findings of the September 2020 accreditation trial and presents the details of the machines that took part in the trial.

2 Trial details

2.1 Participants

Nineteen machines (all trailer-mounted) took part in the 2020 Highways England DPT accreditation trial, comprising thirteen FWDs and six HWDs. A total of eleven 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 8002 FWD
James Fisher Testing Services Ltd.	Grontmij Primax 2500 HWD, Dynatest 8012 FWD
PMS Ltd. (Eire)	Dynatest 8002 FWD
PTS Ltd.	1 × Dynatest 8002 FWD and 3 x Dynatest 8082 HWD
Pulse Surveying Ltd.	2 x Dynatest 8002 FWD
SOCOTEC	RINCENT HeavyDyn
TRL Ltd.	Dynatest 8002 FWD

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

Throughout 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 recommended setup described in CS 229 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. In addition, the operators were asked to carry out additional checks and provide details of the software settings for the trial. The machines were checked by a TRL inspector before testing began to ensure that the geophones were in the correct positions 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), located between the wheelpaths, 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 stations 2, 5 and 8) are used in the repeatability testing. Two additional test lengths were set up; one to allow operators to undertake distance calibrations (if required) 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 by TRL 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. Due to the COVID-19 situation the test process used in previous years was amended to reduce contact between staff on site and the number of staff on site. An outline of the trial programme is presented below.

2.6.1 Day 1 – inspection, repeatability and reproducibility testing

After arrival on site participants were briefed on the test plan and site rules (including COVID safe operations). This was followed by a check on the geophone positions for each device and the repeatability testing.

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 data from the repeatability laps was processed by TRL on site and feedback was provided to operators so that they could investigate their machine if required before they took part in the reproducibility laps.

Once the repeatability laps were completed (and processed) the machines then surveyed the site in convoy to undertake the reproducibility testing.

For the reproducibility testing five replicate drops were made at each of 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.

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.

Data from this testing was sent back (during testing) to staff not on site for processing. Some feedback from this processing was provided during this day, and some was provided on day 2.

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

2.6.2 Day 2 – processing of data and investigation of devices

Day 2 was assigned to the processing and interpretation of the data from day 1 and the investigation of devices not meeting the criteria. Results from the testing on day 1 were provided to the participants before noon on this day. Contractors could then use the afternoon to investigate their devices if required. To reduce the amount of testing required for day 3, some of the devices that underwent minor alterations conducted their repeat repeatability testing on this day.

2.6.3 Day 3 – Repeatability and Reproducibility testing

Day 3 was used to conduct additional reproducibility testing for all devices (following the same procedure as day 1), and to conduct additional repeatability testing for all devices that had undergone alterations during the trial (and had not completed these on day 2).

Data from this testing was sent back to the TRL Crowthorne House office for remote processing. Some feedback was possible on the day to allow further investigation and repeat testing of devices where required.

3 Machine set-up and configuration

Participants were provided vehicle inspection check sheets to complete and provide before the trial. These check sheets contain details on the configuration of the machine and also helped to ensure that the devices were correctly configured for the testing.

Before any testing was conducted on day 1, the positions of the geophones were also checked by TRL staff. During this inspection a few minor adjustments to geophone positions were carried out.

Appendix A itemises the configuration of the various machines, while Table 3.1 summarises the findings with regards to certain key parameters that either affect operation or are requested in the trial documentation.

Table 3.1: Summary of DPT configurations on arrival

Checklist item	Number compliant (out of 19)
Completed Check list returned to TRL before trial	17
Date of last tower calibration	15
Date of last dynamic calibration	17
Date of last manufacturer's calibration	17

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) are shown in Appendix A.

4 Repeatability testing

Since the repeatability test assesses the ability of the device to produce repeatable results, this testing can be carried out at different times for each device (i.e. they do not need to test the site in convoy). The initial test laps for this testing were conducted on day 1 of the trial using stations 2, 5, 8 and 13 and the results were assessed using the test criteria in Appendix D, D.1.

During this testing, issues were identified with the data from four devices (Machines 13, 15, 50 and 51). Two of these devices, 15 and 50, had issues with the setup for the testing (incorrect number of drops in the survey file). Operators of these devices were notified of this issue so that they could rectify before conducting additional repeatability laps at other times during the trial. Machines 13 and 51 both failed the repeatability criteria and were notified of their performance so that they could investigate before taking part in the remainder of the trial.

During the Reproducibility testing (discussed in sections 5 and 6) some additional machines were identified as requiring investigation and subsequently underwent alterations. Any machines that underwent alterations during the trial were required to repeat the repeatability tests after these changes. Table 4.1 shows the summary of the final results for the repeatability assessment for all machines. For this testing there are 56 data points (7 geophones x 4 stations x 2 laps).

Table 4.1: 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	1	0	1	0	0	0	0	96.4%	Pass
5	0	1	0	1	0	0	0	96.4%	Pass
10	0	0	0	0	0	0	0	100.0%	Pass
11	0	0	0	1	0	0	0	98.2%	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
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
39	0	1	0	0	0	0	0	98.2%	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
50	0	0	0	0	0	0	0	100.0%	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 met the Repeatability criteria. The full details of each repeatability test (including load applied) can be found in Appendix E.

5 Reproducibility testing - Day 1

5.1 Temperature variation – Day 1

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.

During the test days of the trial, pavement temperatures were recorded at 40 and 100mm depths near stations 2 and 11. The pavement temperatures for Day 1 are shown in Figure 5.1. The air and surface temperatures were also collected at stations 2 and 11 and the data for day 1 is shown in Figure 5.2.

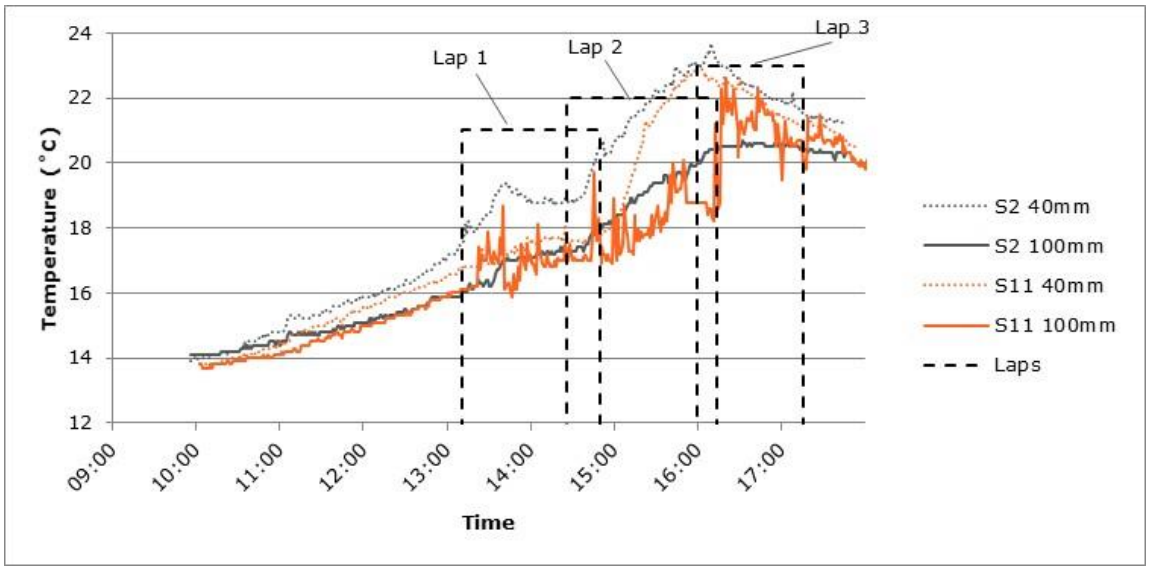

Figure 5.1: Pavement temperatures during day 1

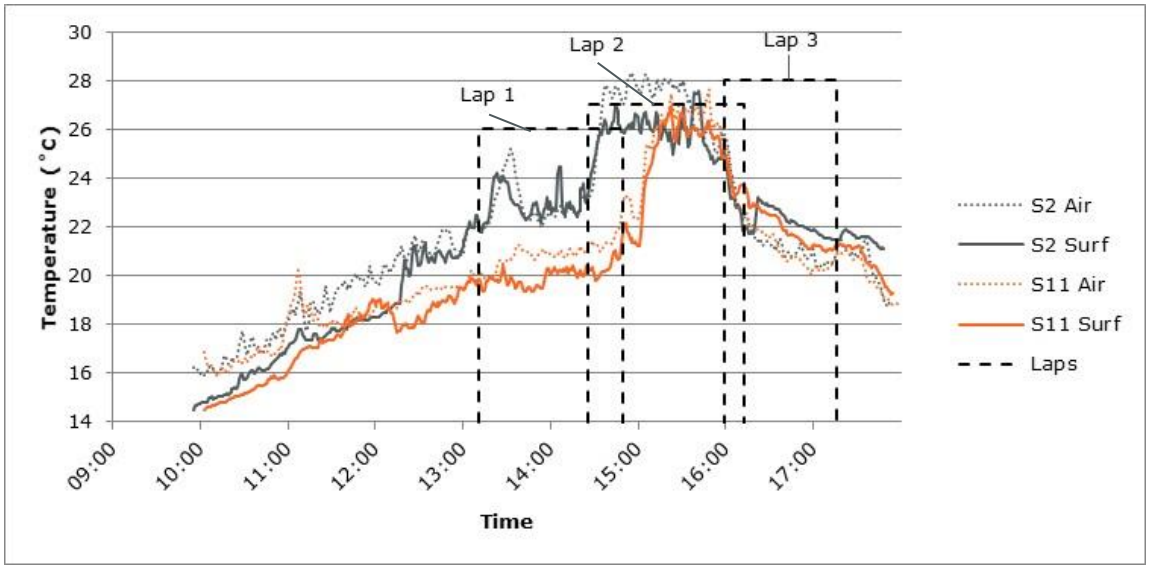

Figure 5.2: Air and surface temperatures during day 1

During the analysis of the data it was noted that the results from 100mm depth for station 11 were noisy. The cause of this noise is not known, but it is recommended that the Auditor for future trials investigates improvements to temperature measurement.

Summaries of the pavement temperature measurements for each test lap on day 1 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 1, 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	13:11	17.5	16.0	14:50	20.5	18.0	01:39	3.0	2.0
2	14:26	18.9	17.3	16:13	23.2	20.4	01:47	4.3	3.1
3	15:59	23.1	20.0	17:16	21.5	20.4	01:17	-1.6	0.4

Table 5.2: Pavement temperatures for each lap during day 1, 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	13:11	16.8	16.1	14:50	17.8	17.6	01:39	1.0	1.5
2	14:26	17.7	17.1	16:13	22.5	21.2	01:47	4.8	4.1
3	15:59	22.9	18.8	17:16	21.1	19.9	01:17	-1.8	1.1

It can be seen that the differences in 100mm depth temperatures was within the limit on laps 1 and 3 but exceeded it on lap 2.

5.2 Reproducibility testing – Day 1

In order to evaluate the performance of each machine with regards to reproducibility, two laps are required (see Appendix D for further details). 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 each reproducibility lap.

During day 1 three laps were undertaken. It was decided that if all machines met the criteria at this stage the testing would end and day 3 would not be used. However, a number of machines did not meet the criteria at this stage. Therefore, the operators were given the opportunity to investigate their machines on day 2, and all machines were retested on day 3. The results of the day 3 testing are discussed in section 6.

The issues identified during the testing on day 1 are summarised below:

- **Machine 5**. During lap 1 this machine was outside of the mean FCF criterion and also the individual SDDR criterion was not met for D6 without the removal of a single data point. This was investigated and the loadcell values were altered between laps

1 and 2. On lap 2 this machine required the removal of a single data point (station 5 D7) before it met the SDDR criteria. The data for lap 3 showed that the machine did not meet the criterion for individual SDDR on two geophones (D6 and D7) and therefore the removal of a single datapoint would not bring this machine within the criteria.

- **Machine 13**. This machine showed poor performance in the repeatability testing. This was investigated and the Series 9000 processor was swapped for a CP15 unit before undertaking the reproducibility testing. This machine did not provide any data for lap 1.
- **Machine 33.** This machine failed to meet the individual SDDR criterion on any lap on day 1. For laps 1 and 3, the criterion was not met for D7 and on lap 2 it was not met for either D6 or D7. In addition, this machine failed to meet the mean FCF criterion on both laps 2 and 3. Between laps 2 and 3 the D7 geophone was swapped for a new geophone but this did not appear to have any effect on the results.
- **Machine 34**. During lap 1 this machine did not meet the mean FCF criterion nor the individual SDDR criterion for D7. This was investigated and the loadcell values were altered between laps 1 and 2.
- **Machine 45.** This machine met the criteria on lap 1 after removal of a single data point (station 5 D7) to meet the individual SDDR criterion for D7. On lap 2 this machine failed to meet the individual SDDR criterion for D7. All criteria were met on lap 3.
- **Machine 47.** The data for lap 1 was truncated and the missing data was not recoverable. Therefore, this lap was not analysed.
- **Machine 50.** This machine failed to meet the FCF criteria on any lap on day 1.
- **Machine 52.** The data for lap 1 was setup for the incorrect number of drops (3 instead of 5). Therefore, this data was not analysed.
- **Machine 53.** This machine was sharing a tow vehicle with Machine 48 and was unable to complete lap 3 within the time available on day 1. In the graphs of FCF and SDDR below, only laps 1 and 2 are shown.

The FCF and SDDR values derived from each machine's lap are given in Appendix F, F.1 (including the laps done on day 3). Plots of the FCF and SDDR values after removal of a single data point, where required, using the full dataset from laps 2 and 3 (laps 1 and 2 for Machine 53) are shown in Figure 5.3 and Figure 5.4 (FCF and SDDR, respectively). 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. 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).

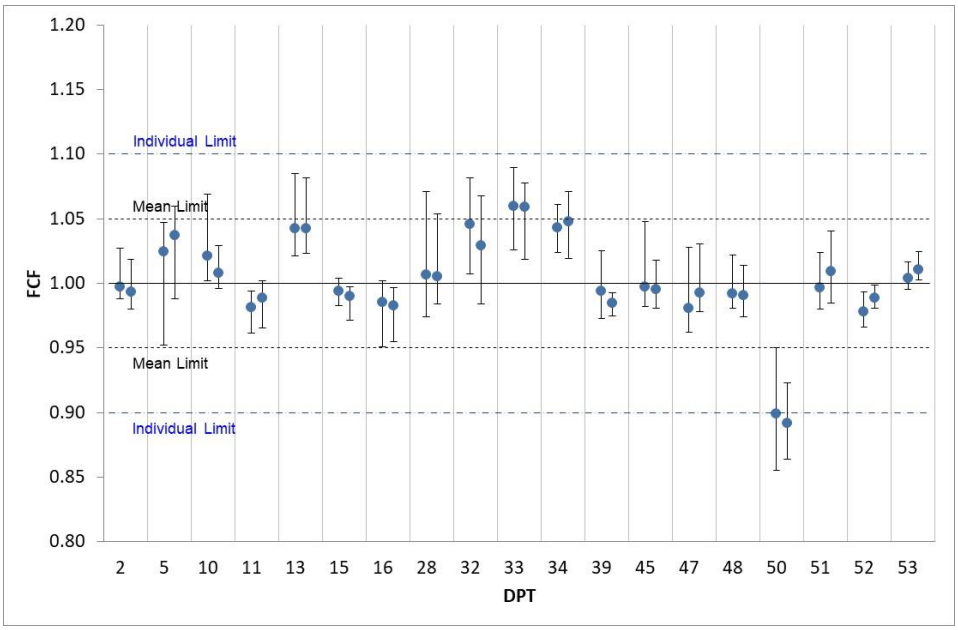

Figure 5.3: FCF for each DPT (day 1 last two laps – full data set)

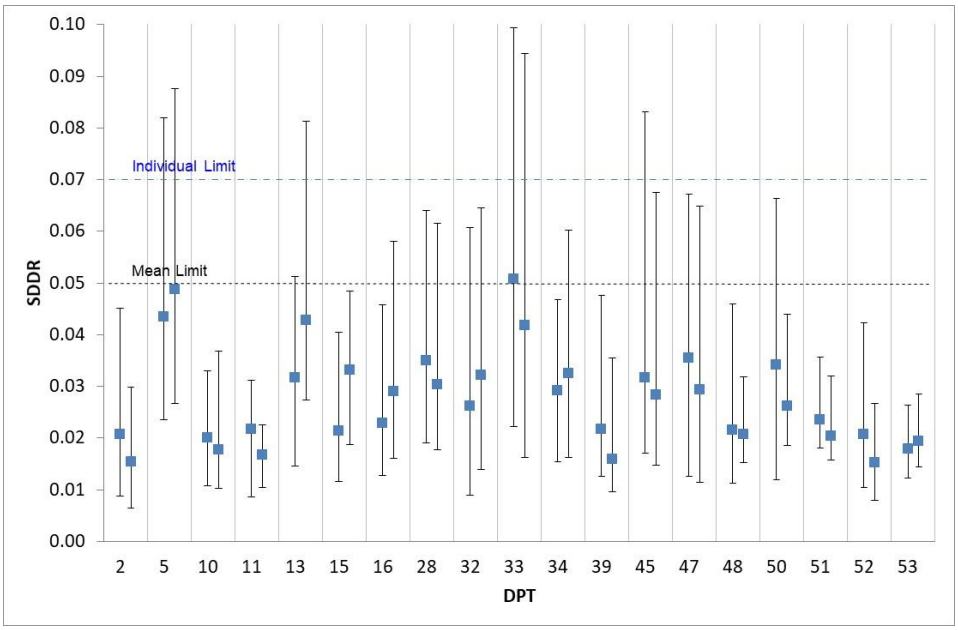

Figure 5.4: SDDR for each DPT (day 1 last two laps – full dataset)

As previously noted, due to chances of isolated anomalous sensor readings, the process permits the measurement from a single sensor from one test station to be removed from each reproducibility lap. The data from the final laps from day 1 after removal of a single data point (where required) are shown in Figure 5.5 and Figure 5.6.

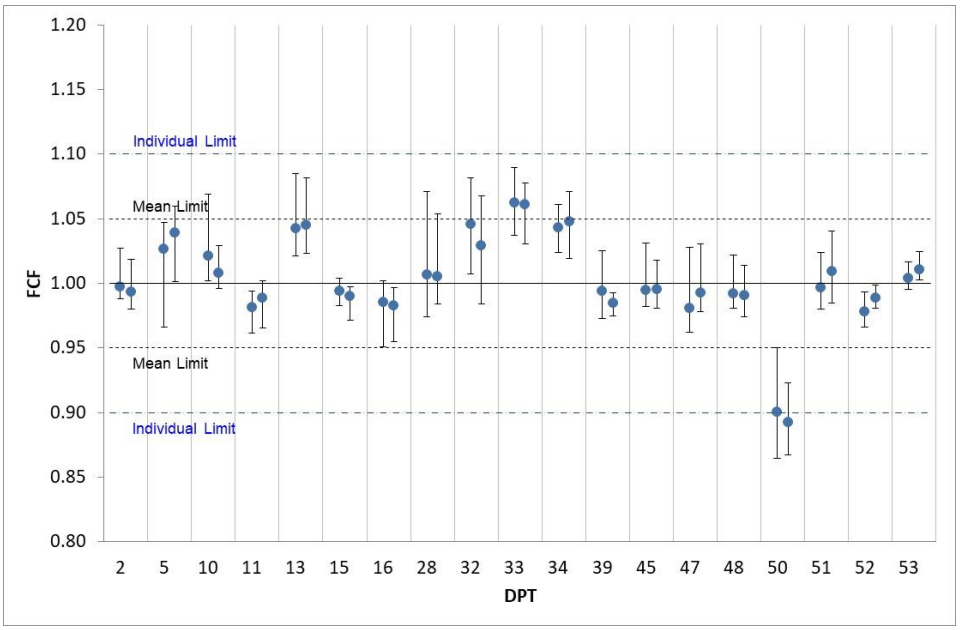

Figure 5.5: FCF for each DPT (day 1 last two laps – single data point removed)

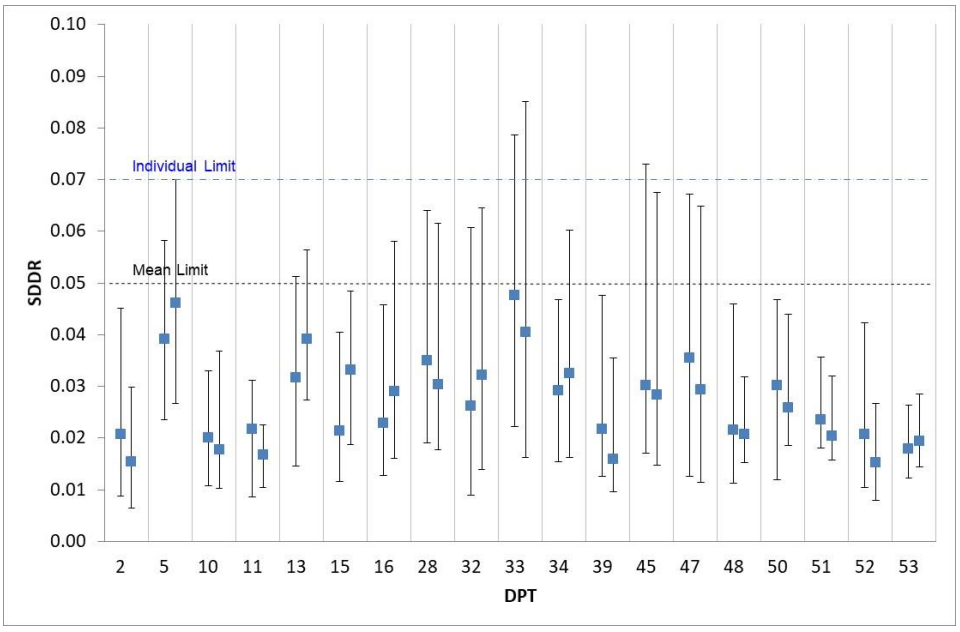

Figure 5.6: SDDR for each DPT (day 1 last two laps – single data point removed)

Following the processing of data from day 1, operators of four machines were asked to investigate their machines before the testing on day 3. These were Machines 5, 33, 45 and 50.

6 Reproducibility testing – Day 3

6.1 Temperature variation – Day 3

The temperatures recorded for the 40 and 100mm depths near stations 2 and 11 for day 3 are shown in Figure 6.1. The data for air and surface temperatures for these stations on day 3 are shown in Figure 6.2. Note: to clearly differentiate between the testing on the two days, the first lap on day 3 was called lap 21.

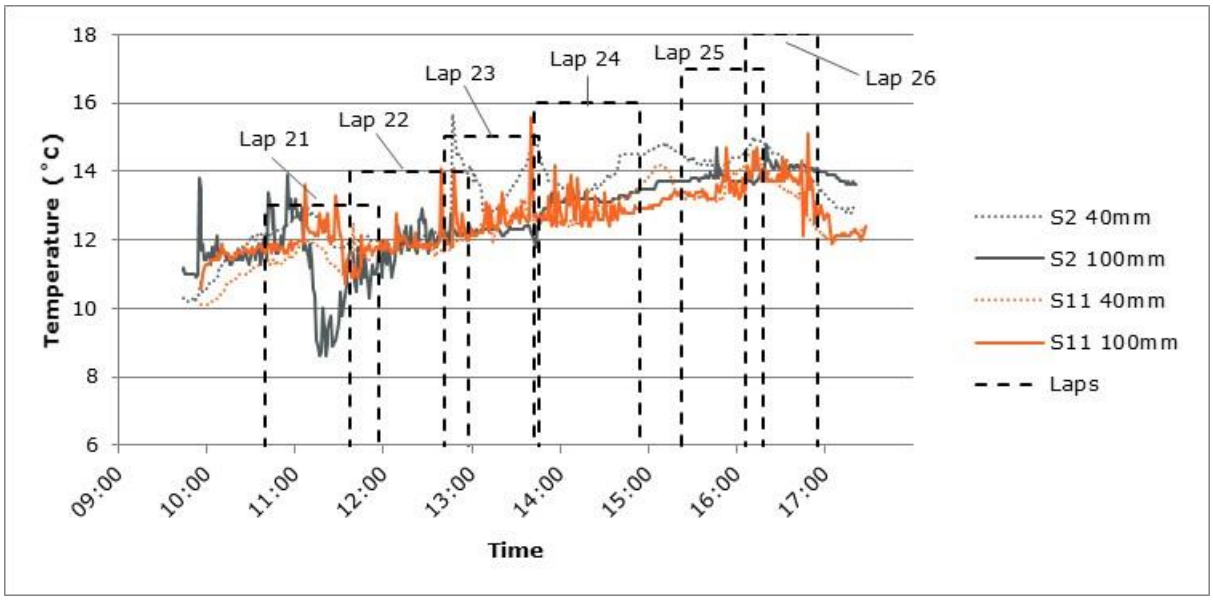

Figure 6.1: Pavement temperatures during day 3

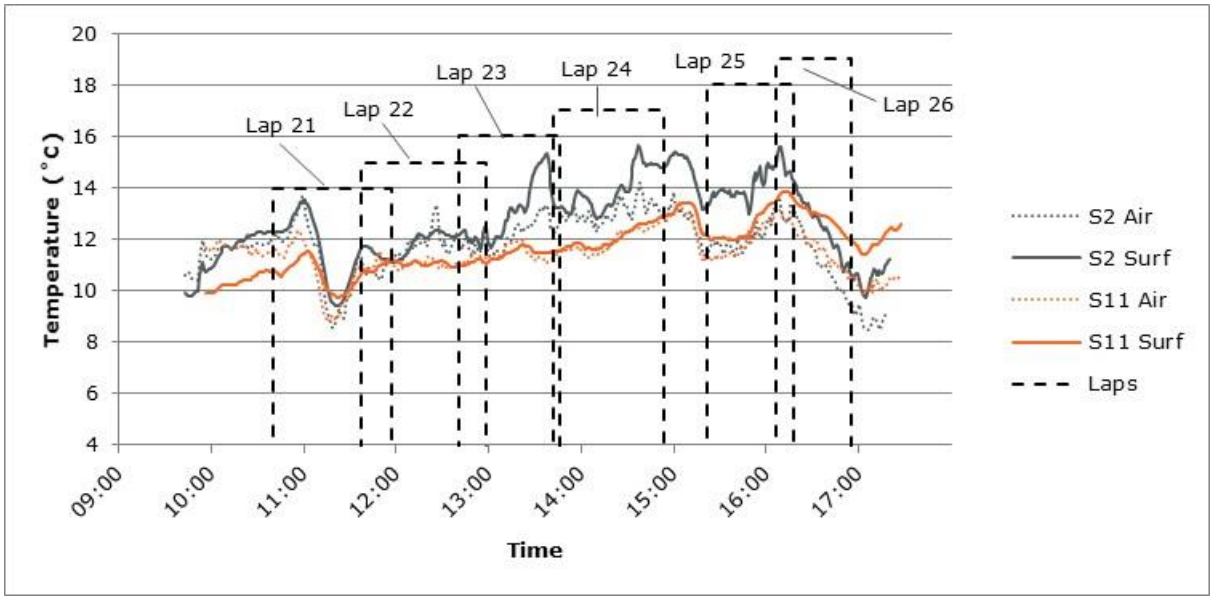

Figure 6.2: Air and surface temperatures during day 3

Summaries of the pavement temperature measurements for each test lap on day 3 are given in Table 6.1 and

Table 6.2 for stations 2 and 11 respectively.

Table 6.1: Pavement temperatures for each lap during day 3, 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
21	10:40	12.1	12.1	11:57	11.9	11.8	01:17	-0.2	-0.3
22	11:37	11.9	11.4	12:58	14.0	12.5	01:21	2.1	1.1
23	12:41	12.2	12.1	13:46	14.5	12.5	01:05	2.3	0.4
24	13:42	14.8	12.1	14:54	14.5	13.4	01:12	-0.3	1.3
25	15:22	14.6	13.7	16:18	14.8	14.1	00:56	0.2	0.4
26	16:06	14.6	13.8	16:55	13.6	14.1	00:49	-1.0	0.3

Table 6.2: Pavement temperatures for each lap during day 3, 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
21	10:40	11.3	11.6	11:57	11.7	11.8	01:17	0.4	0.2
22	11:37	11.2	11.1	12:58	12.2	12.0	01:21	1.0	0.9
23	12:41	11.6	12.5	13:46	12.7	12.7	01:05	1.1	0.2
24	13:42	12.6	13.7	14:54	13.5	12.9	01:12	0.9	-0.8
25	15:22	13.3	13.3	16:18	14.2	13.7	00:56	0.9	0.4
26	16:06	14.2	13.4	16:55	12.3	13.1	00:49	-1.9	-0.3

It can be seen that the differences in 100mm depth temperatures were within the limit (3°C) on all laps for day 3.

6.2 Reproducibility testing – Day 3

As previously noted, to evaluate the performance of each machine with regards to reproducibility, two laps are chosen from the test set. To distinguish these chosen laps, they are denoted as lap i and lap ii. In general, the laps chosen for i and ii were laps 22 and 23 (the second and third laps on day 3). However, in some instances e.g. software failure, missed stations, or machine alterations, this has resulted in different laps being selected. In addition, some devices did not take part in all 6 laps on day 3, for a variety of reasons unrelated to the performance of the DPT device e.g. generator stopped working, additional time issues with sharing a tow vehicle, etc..

The issues identified during the testing on day 3 and the instances where laps 22 and 23 were not used are discussed below:

- **Machine 05**. This machine met all of the FCF and SDDR criteria on lap 21. On laps 22 and 23 it met the FCF criteria using the full dataset and the SDDR criteria after the removal of a single data point on each lap (station 5, D7 in both cases). This machine then took part in the additional testing to support the investigation of devices discussed below (as did most of the attendees). During all of these laps the machine met the FCF criteria. On lap 24 the SDDR criteria were meet after removal of a single data point. On laps 25 and 26 the individual geophone SDDR criterion was not met for D7 (even after removal of a single data point). Although the machine technically met the trial criteria on the assessment laps, the change in performance after these laps warranted further investigation. This is discussed in section 6.3.
- **Machine 11**. During the testing on lap 26 the operator missed a test station. Therefore, this data is not included in the analysis.
- **Machine 33**. This machine was investigated after the testing on day 1. During the testing on day 3, the machine met the FCF criteria on all laps. On lap 21, the SDDR criteria were met after the removal of a single data point. Lap 22 was outside of the individual SDDR criterion for D7. On lap 23 the machine met the SDDR criteria with the full dataset (but was close on the individual SDDR for D7). On lap 24 the machine did not meet the criterion for individual SDDR for D7. Before undertaking lap 25 the channel used for D7 was swapped from 7 to 8 (and the output file amended appropriately). Following this change the machine met all of the criteria for the full data set on lap 25 and with the removal of a single data point on lap 26.
- **Machine 34**. During the testing on laps 21 and 22, this machine was found to be outside the mean FCF criterion. The machine was then investigated and the loadcell offset was amended. This machine then met all of the criteria for the remaining laps (23, 24, 25 and 26) using the full dataset on all laps apart from lap 26 (which required the removal of a single point to meet the individual SDDR criterion).
- **Machine 48.** This machine was sharing a tow vehicle with machine 53 and was unable to take part in lap 23 in the time allowed (but provided data for the other laps on the day).
- **Machine 51.** After the testing on lap 24, the generator for this machine stopped working and therefore did not take part in laps 25 and 26
- **Machine 53.** This machine was sharing a tow vehicle with machine 48 and was unable to take part in laps 25 and 26 in the time allowed (but provided data for the other laps on the day).

The FCF and SDDR values derived from each machine's lap are given in Appendix F, F.1 (including the laps from day 1).

The laps chosen for assessment (lap i and ii) were laps 22 and 23 for most machines apart from the exceptions discussed above, as shown in Table 6.3.

Table 6.3: Machines for which laps 22 and 23 were not used for the assessment

Machine	Lap i	Lap ii
33	25	26
34	23	24

48	22	24

6.2.1 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 6.3 for FCF and Figure 6.4 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.

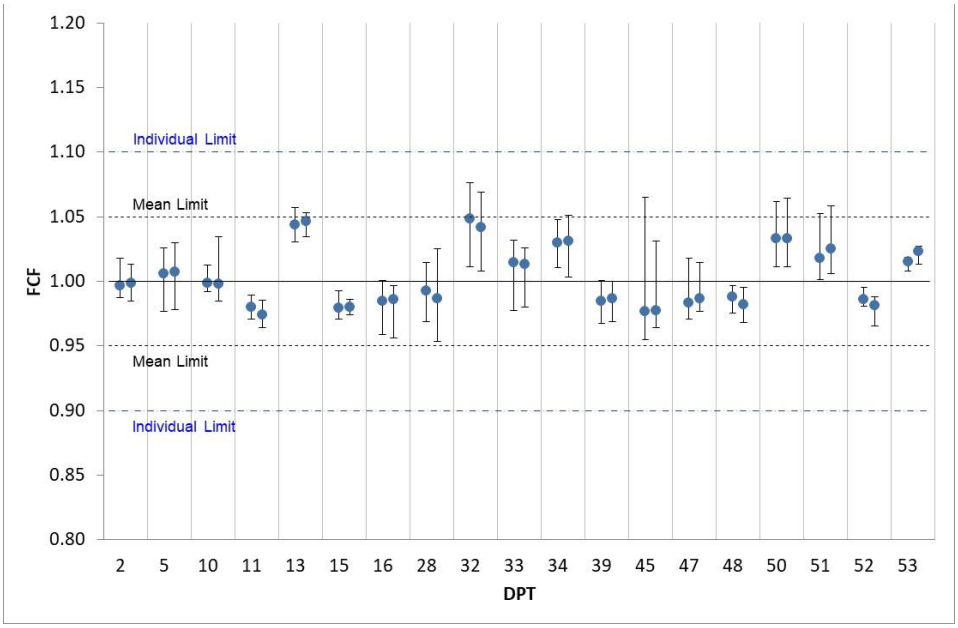

Figure 6.3: FCF for each DPT (day 3 for laps i and ii – full data set)

It can be seen from Figure 6.3 that all machines meet the FCF criteria using the full data set from the two chosen test laps.

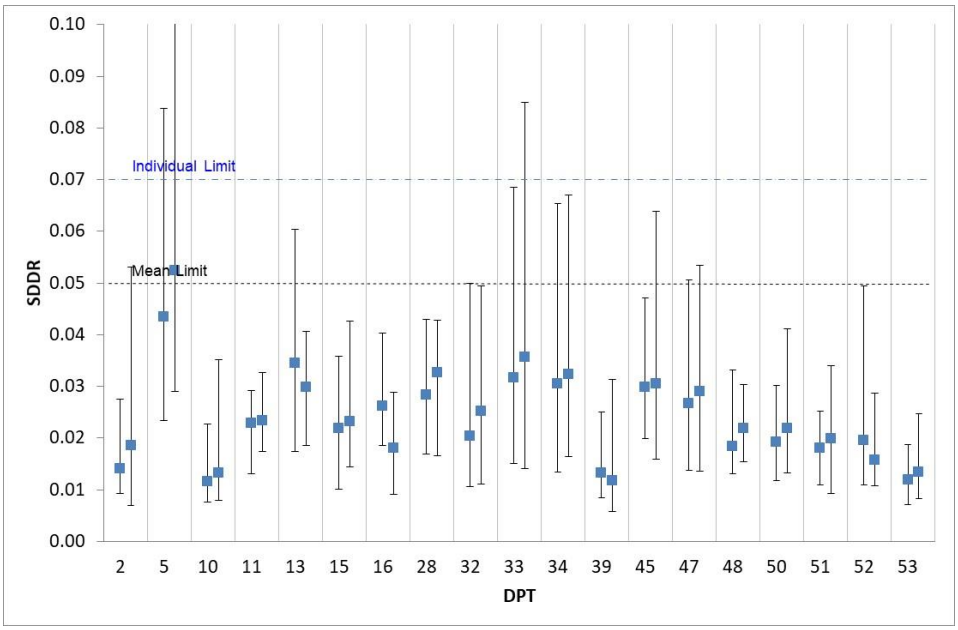

Figure 6.4: SDDR for each DPT (day 3 for laps i and ii – full dataset)

One machine (Machine 5) failed to meet the criterion for the mean SDDR using the full set of data. Two machines (Machine 5 and 33) failed to meet the individual SDDR criterion using the full set of data.

6.2.2 Plots of FCF and SDDR (after geophone removal)

The results from laps i and ii (after geophone removal for identified machines) are shown graphically in Figure 6.5 for FCF and Figure 6.6 for SDDR.

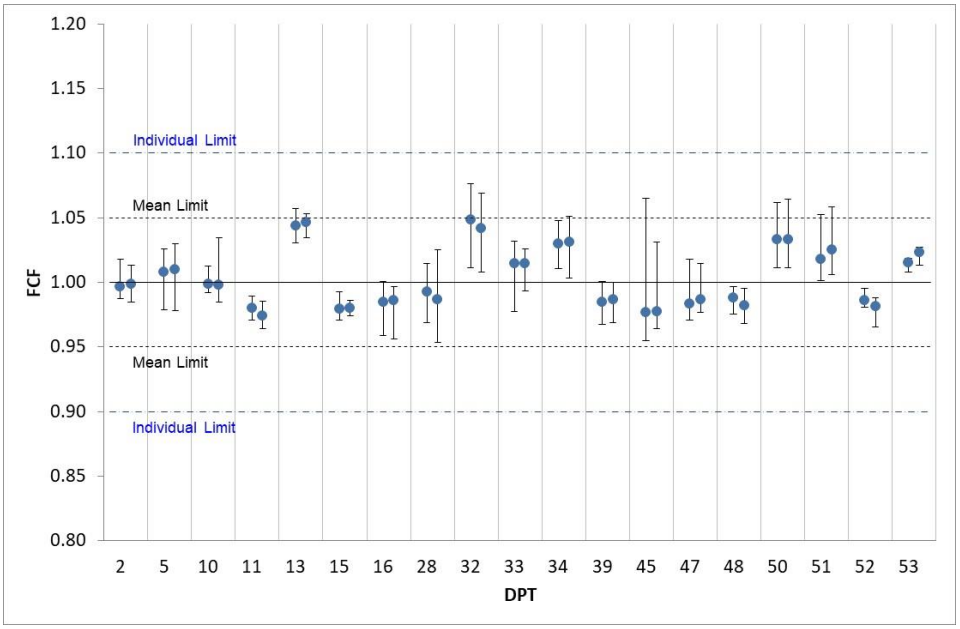

Figure 6.5: FCF for each DPT (day 3 for laps i and ii – single data point removed)

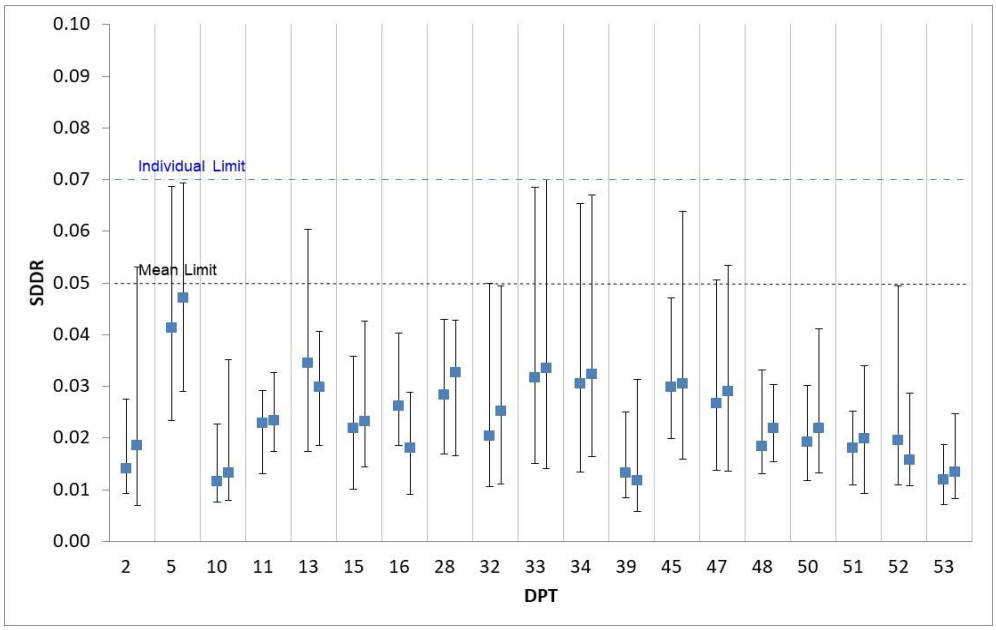

Figure 6.6: SDDR for each DPT (day 3 for laps i and ii – single data point removed)

Following the removal of a single geophone reading from one station on each lap (where required) it can be seen that Machines 5 and 33 now meet the SDDR criteria on the laps selected for laps i and ii.

6.3 Further investigations into Machine 05

Although Machine 05 met the criteria for the laps selected for laps i and ii (after removal of a single data point on each lap) it did not meet it on the last two laps on site (laps 25 and 26) undertaken to support the assessment of machines 33 and 34. A summary of the SDDRs for this machine over the course of the trial is shown in Figure 6.7 (full dataset) and Figure 6.8 (with a single data point removed where required).

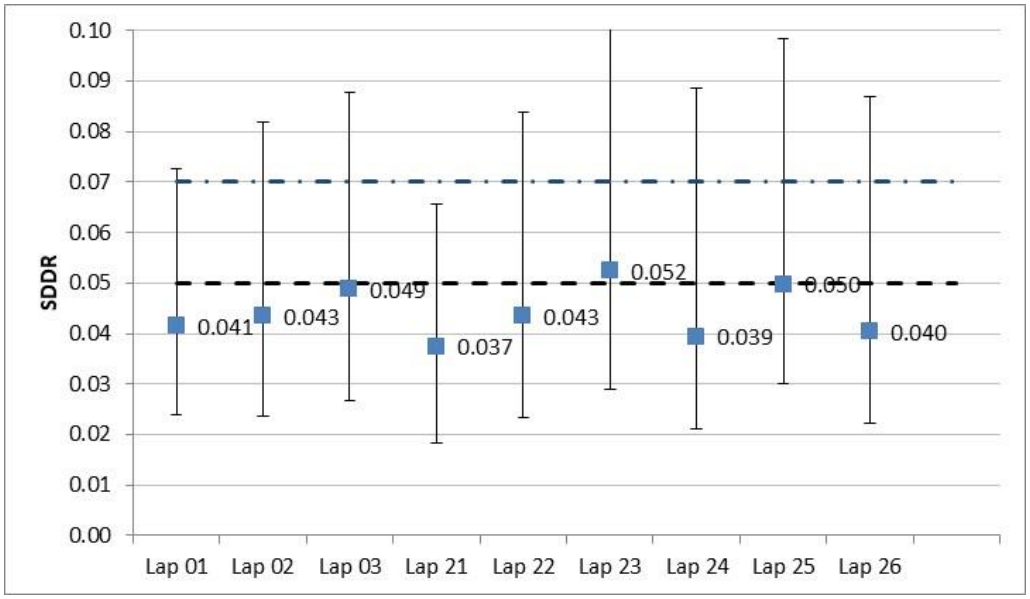

Figure 6.7: SDDR for machine 05 over the course of the trial (full data set)

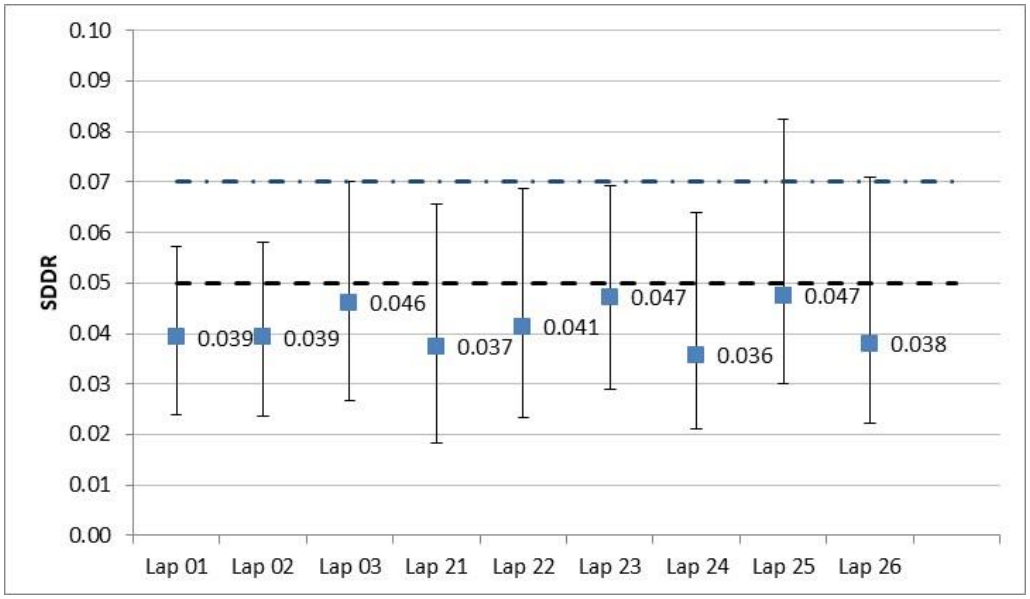

Figure 6.8: SDDR for machine 05 over the course of the trial (single data point removed)

It can be seen from Figure 6.8 that in addition to failing the criteria on laps 25 and 26, the machine comes close to failing on some of the other laps.

Due to this it was decided that this machine should undergo further examination after the trial. An initial investigation of the machine on the Contractor's Calibration site for the owner of the machine (with another device providing reference data) was undertaken. This work demonstrated a similar performance to laps 25 and 26 at the trial.

The machine was sent to the manufacturer for further investigation. On arrival, the manufacturer noticed that geophones D1 and D7 were not correctly fitted in their holders with the bottom of the geophone not fully on the clamping disk. This incorrect fitting was recreated and shown in the image below.

Figure 6.9: Example of how the geophone was incorrectly fitted

The manufacturer was unable to establish whether the geophone came out of the fitting during transport to the site or if the geophone was incorrectly fitted before.

The machine was then tested on the manufacturer's site (with another device providing reference data). The results from this testing showed suitable SDDR performance. This either meant that the problem was fixed between the testing on the two sites, or the manufacturer's site does not include the range of constructions which this machine struggles with. Therefore Machine 05 returned to the Contractor's Calibration site for the owner of the machine to investigate further.

The testing on the owner's Contractor's Calibration site was repeated with two reference devices (the same machine as used before and another one). This was to make sure that the previous reference selected was not skewing the performance. The data was processed a) using both devices as a reference and b) using just the original reference device as the reference. In both cases the data from machine 05 showed suitable SDDR performance.

Therefore, based on the performance on laps 23 and 24 at the trial, and the additional testing post-trial, this machine has been identified as suitable for use.

However, the investigation undertaken did not confirm whether the incorrect fitting of D7 was the cause of the issue, only that the affect appears to have disappeared during the investigation. Therefore, the operator was asked:

- To review their processes in place used to confirm the fitting of the geophones and review training if required. They should also check the magnet fitting for D7 to confirm that this is working suitably or if any alterations need to be made.
- To pay particular attention to D7 for this machine during the ongoing QA for the device.

7 Distance and OSGR

7.1 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, 518m, was not provided to the operators. The criteria applied to this data are described in Appendix D, D.1. The differences between the operator measurements and the reference length are given in Table 7.1 (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 7.1: 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	3.0	2.0	3.0	3.0	Pass
10	2.0	2.0	2.0	2.0	Pass
11	-1.0	-1.0	-1.0	0.0	Pass
13	1.0	0.0	-1.0	-1.0	Pass
15	-2.2	-2.1	-1.6	-1.7	Pass
16	-3.0	-3.0	-3.0	-3.0	Pass
28	-1.0	-1.0	-1.0	-1.0	Pass
32	-3.0	-3.0	-3.0	-3.0	Pass
33	-4.0	-4.0	-4.0	-4.0	Pass
34	-3.0	-3.0	-4.0	-4.0	Pass
39	-1.1	-1.2	-1.0	-1.0	Pass
45	-5.0	-5.0	-5.0	-4.0	Pass
47	3.0	3.0	3.0	4.0	Pass
48	-4.0	-4.0	-4.0	-3.0	Pass
50	-2.6	-2.6	-2.8	-2.6	Pass
51	-2.0	-2.0	-2.0	-1.0	Pass
52	-3.0	-3.0	-3.0	-2.0	Pass
53	-4.0	-4.0	-4.0	-3.0	Pass

It can be seen from this table that all machines met the trial criteria. In addition, 25% of the measurements were within 1m of the reference distance. It is also noted that the machines are generally repeatable (i.e. the difference from the reference is consistent between laps). This suggests that the differences are likely due to differences in the distance calibrations.

7.2 OSGR measurements (from 3-dimensional positional data)

3-dimensional positional data were supplied by 6 of the 19 machines at the trial. These devices all provide the data in lat/long/height format. However, the accreditation specification states that the data should be in OSGR format (eastings and northings). The data has been converted to OSGR format by TRL before assessment against the criteria (given in Appendix D, D.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 therefore 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 7.2. This data is highlighted in bold and red text if the percentage is below 75% for any of the criteria.

Table 7.2: Assessment of positional data

Machine	Percentage of data that is within x m of the reference (horizontally)			Performance band
	2m	5m	10m	
11	95%	100%	100%	High
28	99%	100%	100%	High
39	96%	100%	100%	High
48	83%	100%	100%	High
50	**38%**	95%	100%	Medium
52	95%	100%	100%	High

8 Operator temperature measurements

8.1 Temperature at depth (100mm)

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 operators were asked to take measurements on each of the reproducibility laps for both test days. The temperatures recorded by the operators are plotted against the data recorded from the temperature data logger (located in the same hole) in Figure 8.1 and Figure 8.2 for the testing on Day 1, and in Figure 8.3 and Figure 8.4 for day 3 testing.

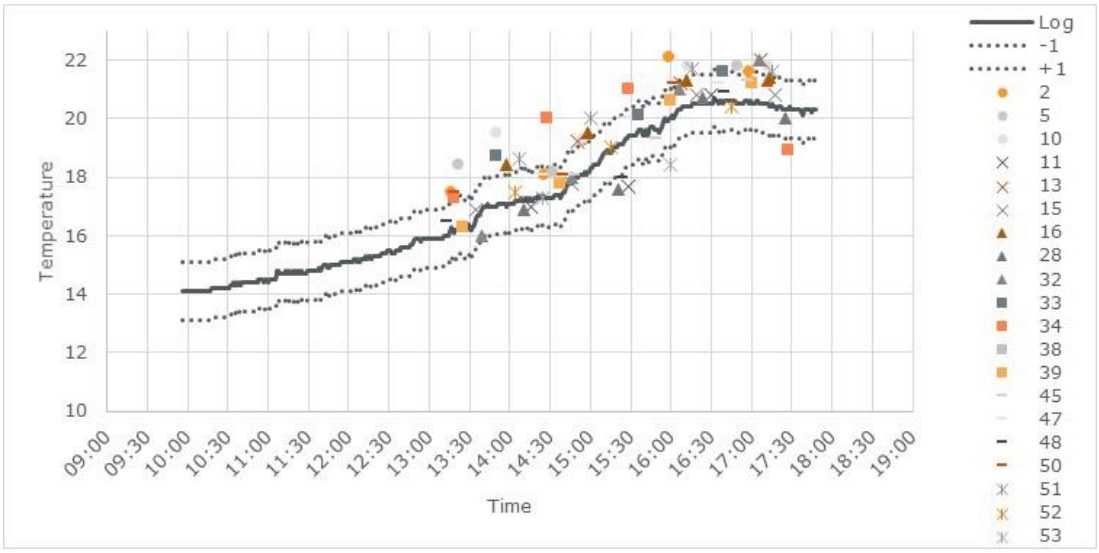

Figure 8.1: Operator's and logger temperatures (day 1 near station 2, 100mm depth)

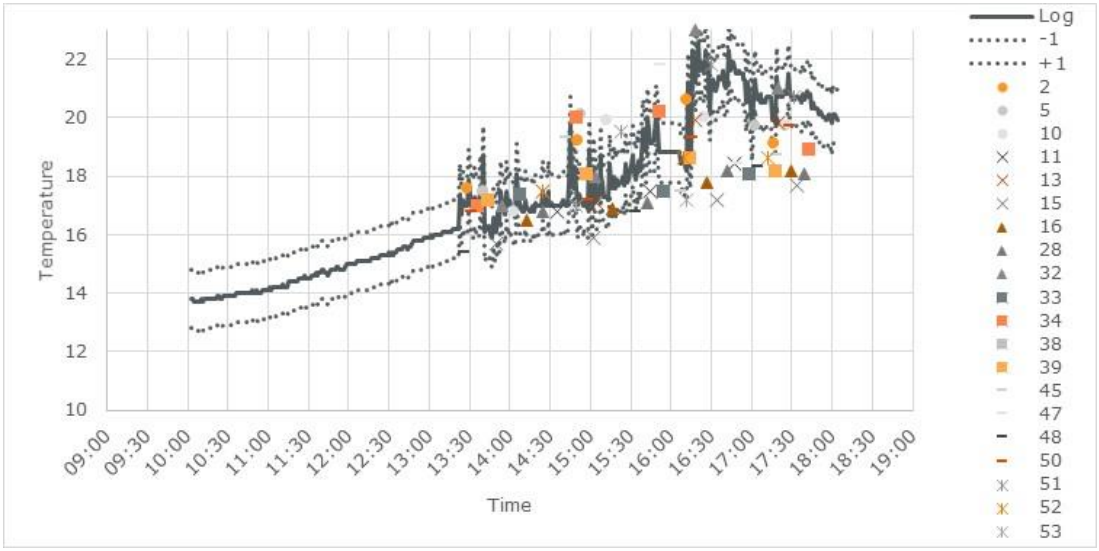

Figure 8.2: Operator's and logger temperatures (day 1 near station 11, 100mm depth)

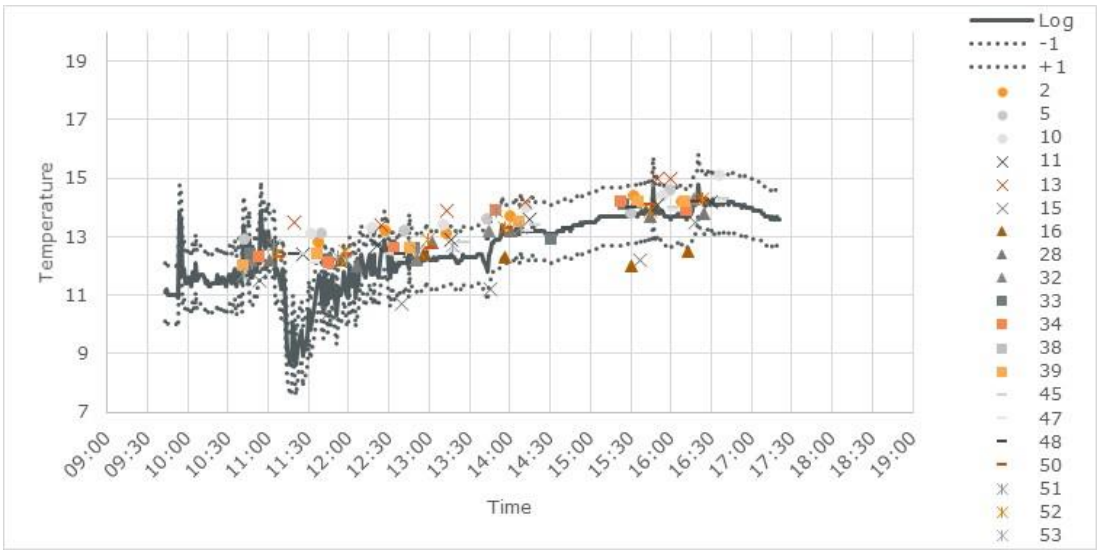

Figure 8.3: Operator's and logger temperatures (day 3 near station 2, 100mm depth)

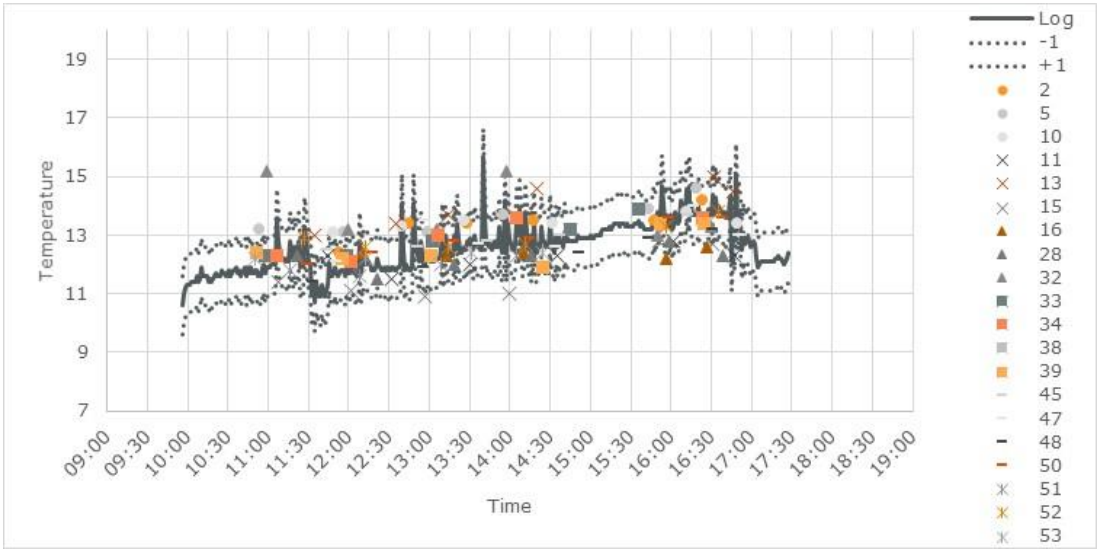

Figure 8.4: Operator's and logger temperatures (day 3 near station 11, 100mm depth)

It can be seen from these plots that the operators' measurements are around the same range of the logger measurements, but in some areas there are some differences.

The test criteria for temperature measurement at depth are given in Appendix D, D.1, and the machines were assessed using all data supplied. The differences and ratings given are presented in Table 8.1. In the table, values are highlighted in bold and red font if the value was more than 1˚C away from the reference.

Table 8.1: Assessment of operators' temperature measurement at depth (stations 2 and 11)

Machine	Difference between operators' measurement and reference data (˚C)																				Percentage within 1˚C	Rating
	Lap 1		Lap 2		Lap 3		Lap 4		Lap 21		Lap 22		Lap 23		Lap 24		Lap 25		Lap 26			
	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11		
2	1.2	0.6	0.8	1.6	2.1	2.4	1.1	-1.0	1.1	0.8	0.7	1.5	0.8	0.9	0.6	0.9	0.6	0.0	0.4	0.5	65%	Medium
5	2.2	0.3	0.9	2.9	1.3	-0.9	.	.	-0.1	1.5	1.5	1.3	0.9	0.8	1.6	1.3	0.0	0.7	1.0	0.9	56%	Low
10	2.5	-0.1	1.2	2.6	1.4	-1.5	1.3	-1.2	3.3	1.3	1.6	-0.8	1.1	1.0	0.8	0.6	0.5	-0.8	1.0	-0.1	45%	Low
11	-0.2	-0.2	-1.7	-1.6	0.3	-3.5	.	.	3.5	1.2	0.8	-0.3	0.6	-0.7	0.4	-0.7	0.2	-0.4	0.1	-1.1	67%	Medium
13	1.2	-0.1	0.9	-1.8	1.5	-0.9	.	.	4.1	2.3	1.2	1.6	1.6	0.9	1.0	2.2	1.1	0.6	1.4	2.4	33%	Low
15	0.3	-0.4	0.0	-1.1	0.3	-3.7	0.4	-3.0	-0.9	-1.4	-0.3	-0.9	-1.4	-1.1	-1.3	-1.9	-1.6	-1.0	-0.6	-1.0	55%	Low
16	1.4	-0.4	1.3	-0.8	0.9	-4.1	1.0	-2.5	.	.	1.2	0.7	0.2	-0.7	-0.8	-0.2	-1.8	-1.2	-1.2	-1.1	50%	Low
28	-0.3	-0.7	-1.5	-1.7	0.2	-2.8	-0.3	-2.7	-1.0	-0.2	1.1	-0.4	0.6	-0.3	0.1	-0.1	-0.1	-0.5	-0.3	-1.4	70%	Medium
32	-0.9	-0.5	0.2	-0.3	0.7	1.3	1.5	0.3	0.3	3.5	0.8	1.5	0.0	1.0	0.8	1.0	0.4	-0.6	0.3	-0.4	80%	High
33	1.7	0.0	0.5	-1.3	1.1	-3.1	.	.	0.5	0.3	0.8	0.7	0.4	0.7	-0.2	0.4	0.4	0.5	0.2	-0.1	78%	Medium
34	1.2	0.0	2.7	1.7	1.6	0.5	-1.4	-1.8	-0.1	-1.3	1.4	0.1	0.5	0.8	1.0	0.9	0.5	.	0.3	-0.1	58%	Low
39	0.0	1.0	0.4	1.1	0.6	-1.0	0.7	-1.6	-1.4	0.6	1.0	0.4	-0.2	0.0	0.4	-1.4	0.4	-0.3	0.5	-0.3	80%	High
45	0.1	2.3	-0.3	-1.3	0.7	-2.7	.	.	2.8	1.4	0.2	0.3	0.4	0.1	0.2	0.0	0.3	-0.4	0.1	0.5	72%	Medium
47	0.7	-1.4	0.7	3.0	0.7	-3.1	.	.	1.4	0.2	0.2	1.5	0.3	0.1	0.0	0.2	0.2	0.3	0.0	-0.8	72%	Medium
48	0.5	-1.8	-1.1	-1.1	0.3	-2.3	.	.	3.0	0.1	0.4	-0.2	.	.	0.0	-0.5	0.2	-0.3	0.1	-0.5	69%	Medium
50	1.4	-0.2	0.6	0.2	1.2	0.5	0.6	-1.8	0.8	-0.9	1.4	0.6	0.4	0.5	0.2	0.4	0.3	0.3	0.1	-0.1	80%	High
51	1.4	0.0	1.7	1.7	1.2	1.6	1.1	0.1	0.1	-0.3	1.4	-0.1	0.3	-0.6	1.0	-0.4	.	.	.	.	56%	Low
52	0.3	0.0	0.2	0.0	-0.2	-2.1	.	.	0.5	0.9	0.7	0.6	0.6	-0.2	0.2	0.1	0.1	-0.1	0.0	0.0	94%	High
53	-0.1	-1.3	-1.6	-1.0	.	.	.	.	-1.7	0.5	0.7	0.2	0.3	-0.3	0.2	-0.4	.	.	.	.	75%	Medium

It can be seen from this table that four machines achieved the high performance rating, eight machines achieved a medium and seven achieved a low performance.

8.2 Contactless surface and air temperature measurements

A methodology for estimating the temperature at 100mm has been developed and is given in the Design Manual for Roads and Bridges (DMRB CS 229, 2020). 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.

The data from the surface measurements are shown in 8.2.1 and air measurements are shown in 8.2.2. The data is compared against the criteria and discussed in 8.2.3.

8.2.1 Surface temperature measurements

Of the nineteen machines which took part in the trial, ten machines (10, 34, 39, 45, 47, 48, 50, 51, 52 and 53) had surface temperatures in their datasets which changed during testing. Some machines had fixed values, and this has been noted on the Accreditation Certificate for the corresponding machine. The surface temperature data from stations 2 and 11 for these machines are shown along with surface temperature data from the logger in Figure 8.5 and Figure 8.6 respectively for day 1, and in Figure 8.7 and Figure 8.8 for day 3.

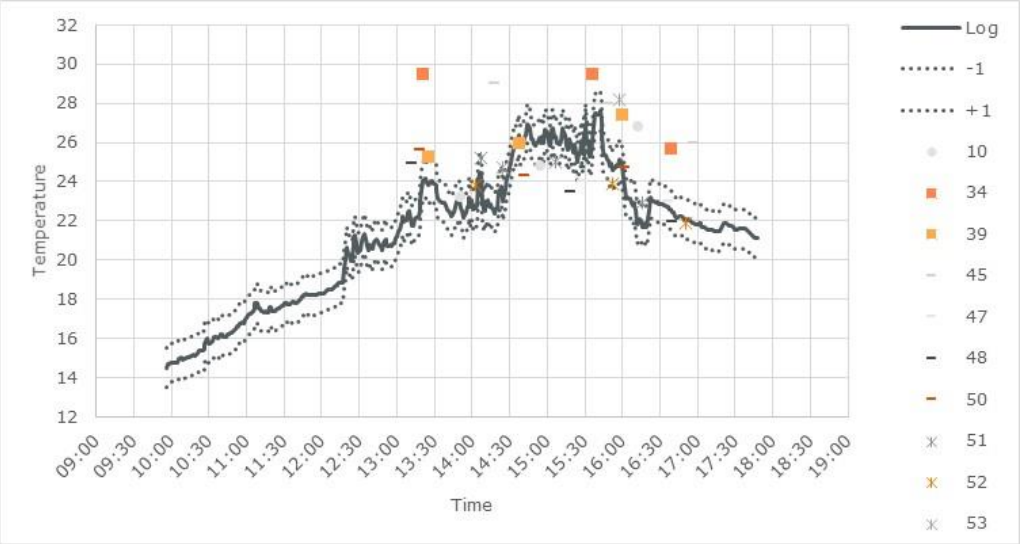

Figure 8.5: Operator's and logger Surface temperatures (day 1 near station 2)

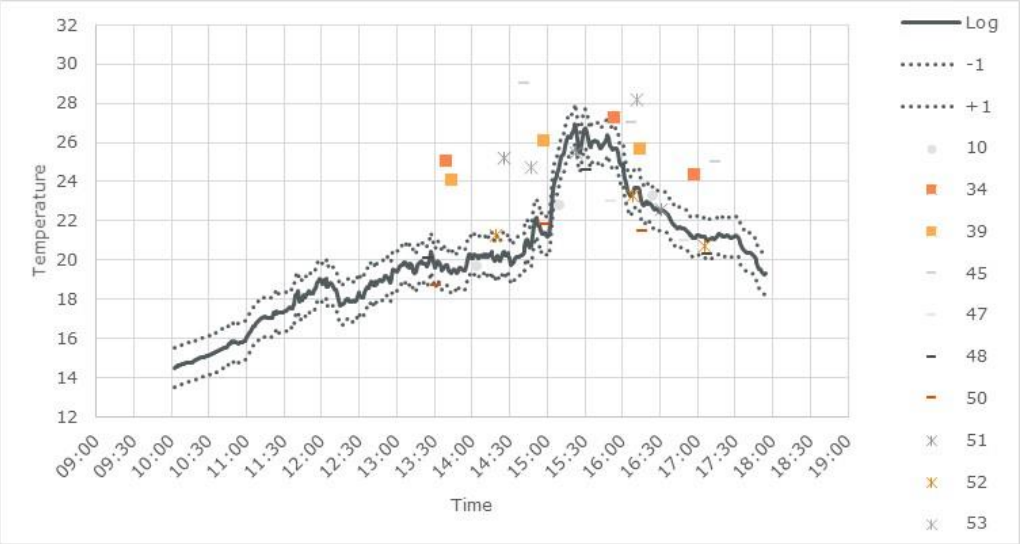

Figure 8.6: Operator's and logger Surface temperatures (day 1 near station 11)

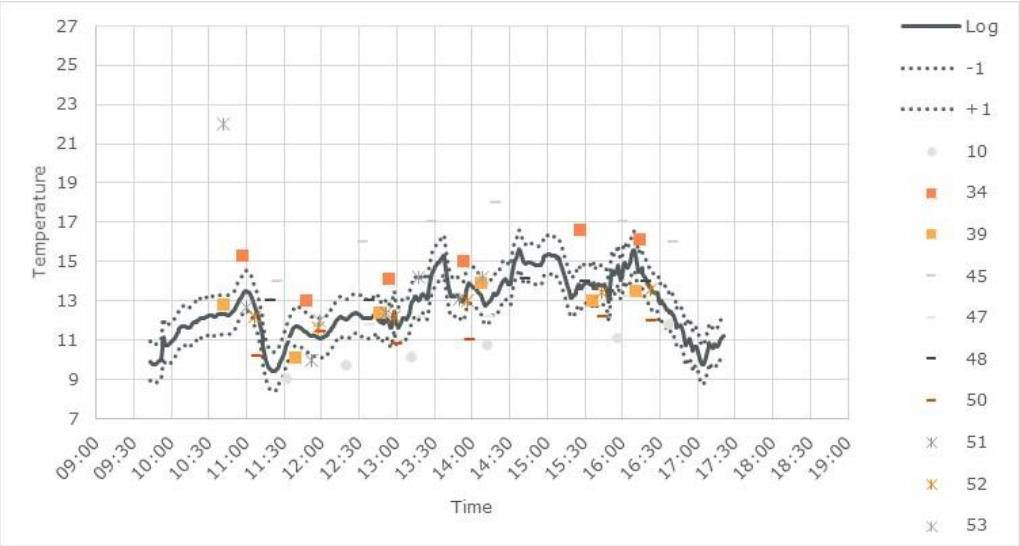

Figure 8.7: Operator's and logger Surface temperatures (day 3 near station 2)

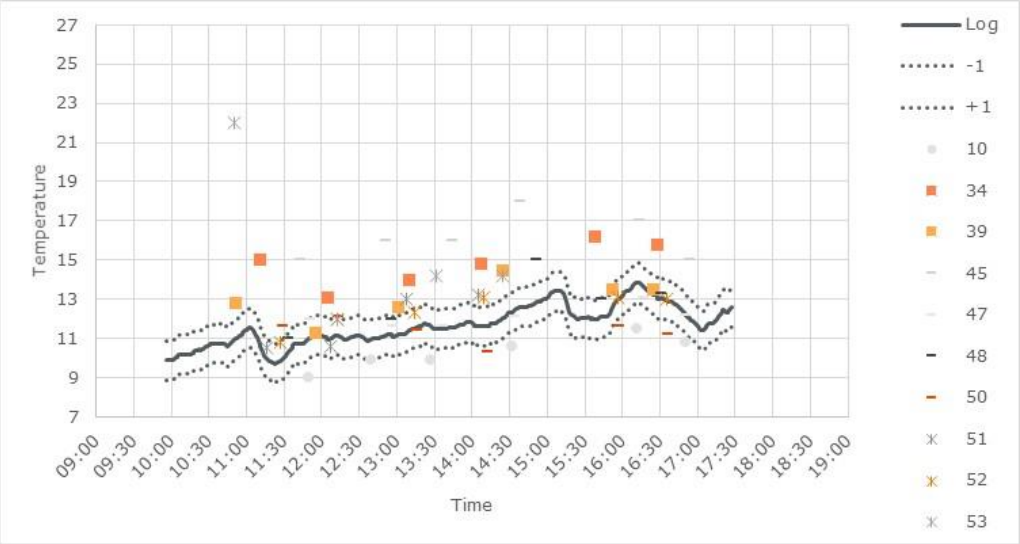

Figure 8.8: Operator's and logger Surface temperatures (day 3 near station 11)

It can be seen from these plots that the there is a spread in the operators' measurements with some below the logger values and some above.

8.2.2 Air temperature measurements

Eleven machines (15, 32, 34, 39, 45, 47, 48, 50, 51, 52 and 53) provided air temperatures in their datasets that changed during testing. However, one machine (Machine 15) only provided the data on day 1. The air temperature data from stations 2 and 11 for these machines are shown along with air temperature data from the logger in Figure 8.9 and Figure 8.10 respectively for day 1, and in Figure 8.11 and Figure 8.12 for day 3.

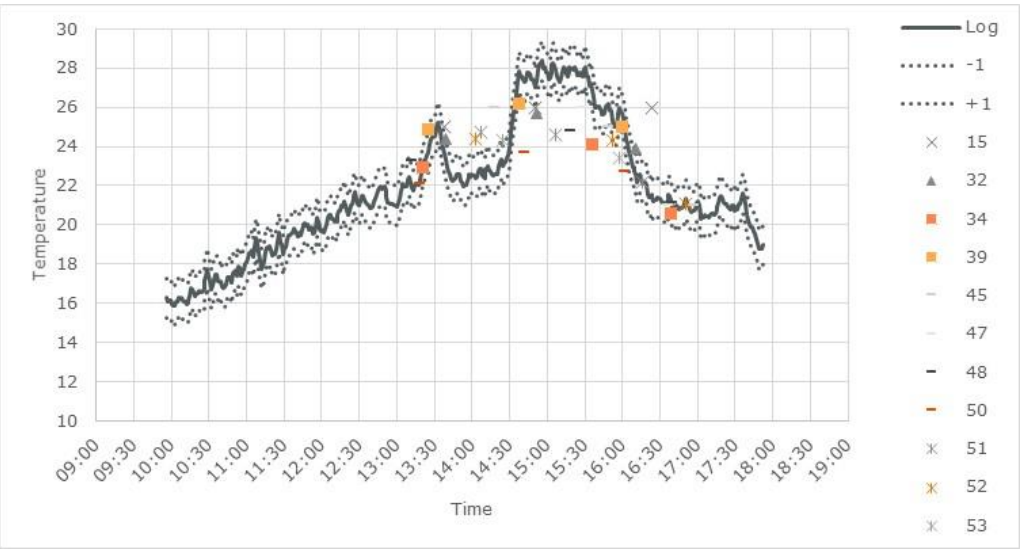

Figure 8.9: Operator's and logger Air temperatures (day 1 near station 2)

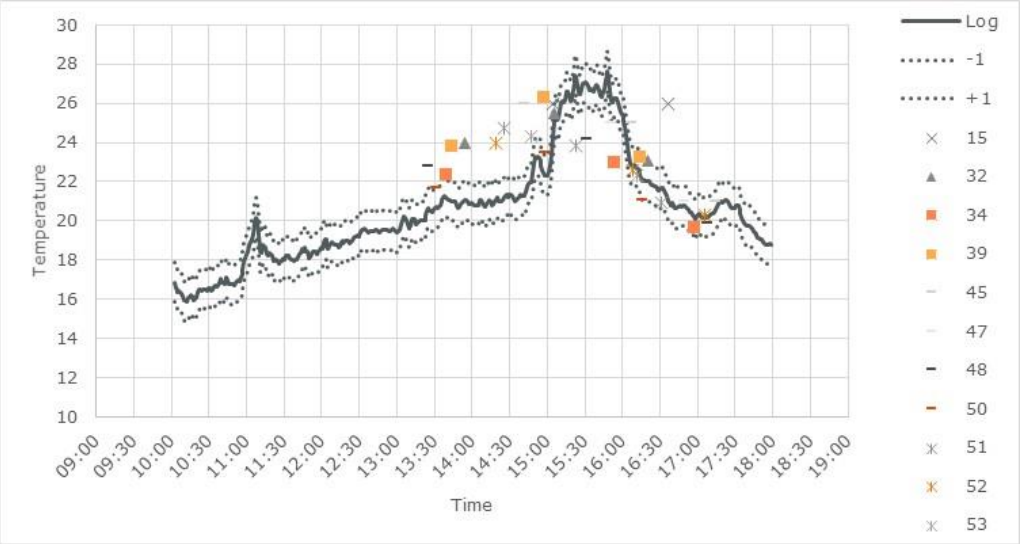

Figure 8.10: Operator's and logger Air temperatures (day 1 near station 11)

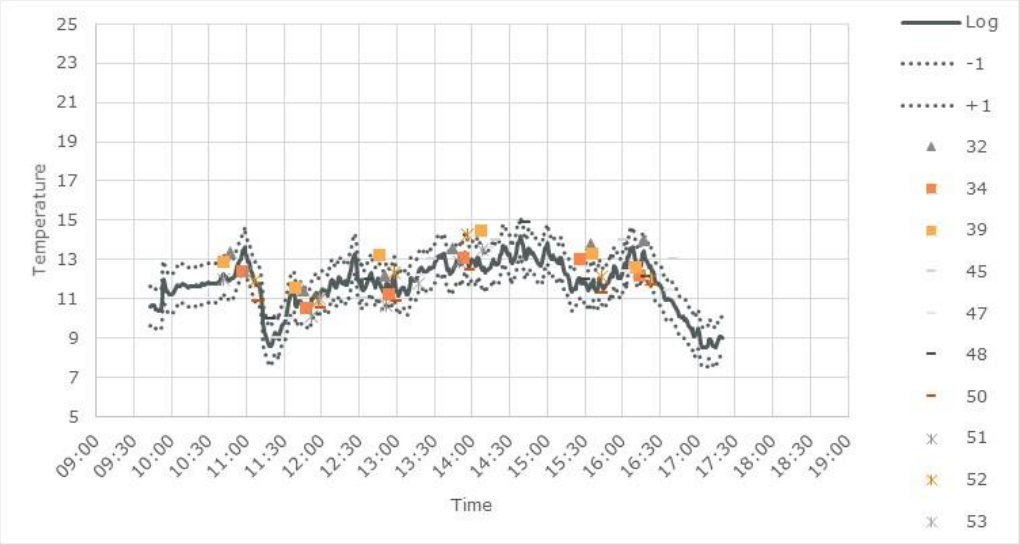

Figure 8.11: Operator's and logger Air temperatures (day 3 near station 2)

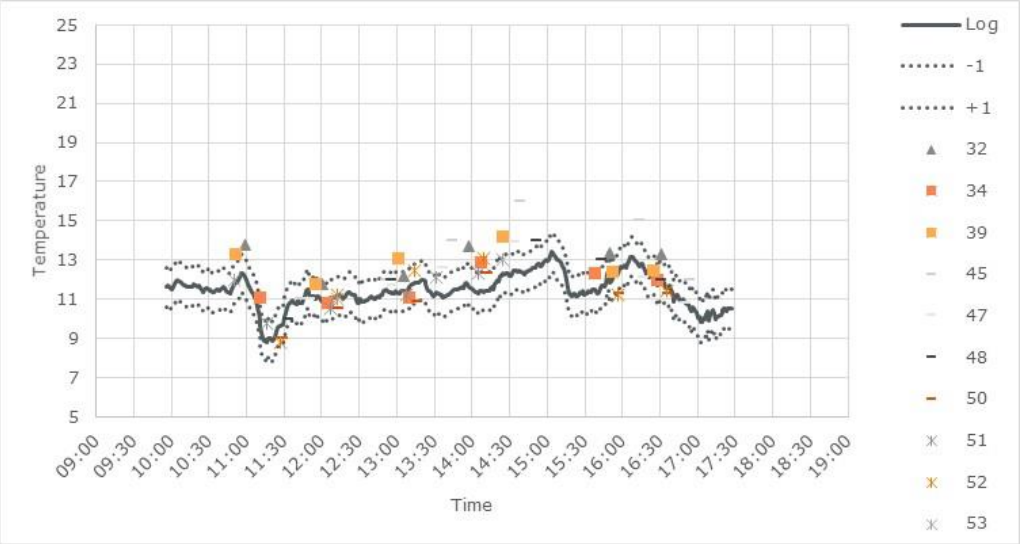

Figure 8.12: Operator's and logger Air temperatures (day 3 near station 11)

It can be seen from these plots that the there is a spread in the operators' measurements with some below the logger and some above.

8.2.3 Assessment of air and surface temperature measurements

The test criteria for surface temperature measurement are given in Appendix D, D.2, and the machines were assessed on all supplied data. The differences and ratings given are presented in Table 8.2. In the table, values are highlighted in bold and red font if the value was more than 1˚C away from the reference.

Air temperature measurements from DPTs at the time of testing are not used for the contactless 100mm temperature calculation method and there are no formal criteria set for this measurement. However, it seemed prudent to assess the data supplied by the machines, therefore the criteria for the surface measurements was applied. The differences and ratings are presented in Table 8.3.

Table 8.2: Assessment of operators' surface temperature measurement (stations 2 and 11)

Machine	Difference between operators' measurement and reference data (˚C)																		Percentage within 1˚C	Rating
	Lap 1		Lap 2		Lap 3		Lap 4		Lap 21		Lap 22		Lap 23		Lap 24		Lap 25		Lap 26			
	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11		
10	0.5	-0.5	-1.2	-1.8	4.9	0.7	.	.	-1.6	-2.0	-2.4	-1.1	-2.6	-1.8	-2.2	-1.7	-3.7	-2.3	-0.6	-1.4	22%	Not Suitable
34	5.5	5.4	3.4	1.7	3.1	3.3	.	.	2.0	4.2	1.6	2.1	2.2	2.6	2.0	3.2	2.8	4.2	1.5	2.7	0%	Not Suitable
39	1.5	4.7	-0.4	4.8	2.6	2.1	.	.	0.5	1.9	-1.6	0.1	0.4	1.4	0.5	2.5	-0.8	1.1	-1.8	0.3	39%	Low
45	6.6	8.6	2.9	3.7	4.1	3.9	.	.	4.4	4.3	3.8	4.9	2.8	4.4	4.6	5.4	2.2	3.2	3.8	3.0	0%	Not Suitable
47	.	.	-1.4	-2.9	0.3	-0.6	.	.	-0.2	1.0	-0.3	0.5	-1.1	0.1	-0.7	-0.3	-1.6	-0.6	0.6	0.0	75%	Medium
48	3.1	0.4	-2.5	-1.9	-0.5	-0.7	.	.	3.5	0.7	0.9	0.8	.	.	-0.8	2.1	0.1	0.9	-0.2	0.3	69%	Medium
50	3.1	-1.0	-2.0	0.4	1.0	-1.6	.	.	-2.2	1.7	0.3	1.0	-1.1	-0.1	-2.9	-1.4	-1.6	-1.4	-1.7	-1.7	22%	Not Suitable
51	0.7	4.8	-1.3	-1.5	1.2	0.1	.	.	-0.8	0.4	-1.2	-0.4	0.3	1.7	-0.1	1.6	.	.	.	.	50%	Low
52	1.1	1.4	-0.7	-0.1	-0.2	-0.5	.	.	-0.5	1.0	0.4	0.8	-0.3	0.8	-0.5	1.5	-0.4	0.1	-0.1	0.0	83%	High
53	1.6	4.0	3.1	4.5	.	.	.	.	9.7	11.1	0.9	0.8	1.1	2.7	0.9	2.2	.	.	.	.	25%	Low

Table 8.3: Assessment of operators' air temperature measurement (stations 2 and 11)

Machine	Difference between operators' measurement and reference data (˚C)																		Percentage within 1˚C	Rating
	Lap 1		Lap 2		Lap 3		Lap 4		Lap 21		Lap 22		Lap 23		Lap 24		Lap 25		Lap 26			
	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11	2	11		
15	1.4	.	-1.0	1.7	4.4	5.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20%	Not Assessed
32	1.1	3.0	-1.6	0.4	1.2	1.0	.	.	1.5	1.6	0.7	0.9	0.8	0.8	1.2	1.9	2.0	1.0	0.8	1.4	39%	Low
34	-0.1	1.1	-2.8	-3.0	-0.7	-0.6	.	.	-1.0	1.1	-0.2	-0.1	-0.4	-0.5	0.3	1.5	1.0	0.8	-0.7	0.3	67%	Medium
39	1.2	2.8	-1.5	3.7	-0.7	0.7	.	.	0.6	1.5	0.7	0.6	1.1	1.8	1.7	2.0	1.5	0.5	-0.3	0.2	44%	Low
45	3.4	4.7	-1.2	2.0	0.3	0.5	.	.	0.0	0.2	-0.5	0.6	0.5	2.6	1.1	3.6	1.4	2.3	2.3	1.5	39%	Low
47	.	.	-1.6	-1.6	-0.3	0.2	.	.	-1.1	-0.3	-0.2	0.4	-0.4	1.5	1.1	1.4	-0.4	-0.7	0.4	0.0	63%	Medium
48	1.4	2.3	-3.2	-2.8	0.3	-0.3	.	.	1.4	-0.7	0.0	0.7	.	.	1.9	1.3	0.1	1.4	-0.9	0.1	50%	Low
50	-0.1	1.0	-3.6	1.1	-2.3	-1.1	.	.	-0.8	-0.7	-0.7	-0.7	-0.7	-0.9	-0.3	0.9	-0.2	-1.3	-1.0	-0.3	72%	Medium
51	1.8	3.5	-3.3	-3.6	0.1	-0.7	.	.	-1.0	0.9	-0.8	-0.5	-1.1	-0.2	0.0	0.9	.	.	.	.	64%	Medium
52	2.0	3.0	-1.0	-0.2	-0.2	0.0	.	.	0.0	-0.8	-0.4	0.1	0.1	0.7	1.0	1.7	0.3	-1.0	-0.6	-0.2	83%	High
53	1.2	2.4	-2.6	-0.4	.	.	.	.	-0.3	0.3	0.0	-0.1	-0.3	0.7	0.9	0.7	.	.	.	.	75%	Medium

From Table 8.2 it can be seen that for the surface temperature measurements, one machine achieved a high performance, two a medium performance, three a low and four were identified as not suitable.

Table 8.3 shows that for the air temperature measurements, one machine achieved a high performance, five a medium performance, four a low performance and one was identified as not suitable.

9 Summary of trial findings

The 2020 UK DPT accreditation trial was held at Horiba-MIRA between the 22nd and 24th September 2020. Nineteen 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 nineteen machines met the trial requirements for the Repeatability assessment.

(ii) Reproducibility of Deflections

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

(iii) Distance measurement

- All nineteen 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

- Six machines provided 3-dimensional positional data in lat/long/height format. After conversion of the data into OSGR format (by TRL), five machines were identified as having achieved a high performance level and one a medium performance level. 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 therefore consideration should be given to imposing the requirement of providing the data in OSGR format.

(v) Temperature measurement at depth (100mm)

- All nineteen operators of the machines provided 100mm pavement temperature measurements using hand held probes. Four achieved a high performance rating, eight achieved a medium and seven achieved a low performance.

(vi) Surface temperature measurement

- Ten machines provided surface temperature measurements using IRTs fixed to their machines. One machine achieved a high performance, two a medium performance, three a low and four were identified as not suitable.

(vii) Air temperature measurement

- Eleven machines provided air temperature measurements from apparatus fixed to their machines. One of these machines did not provide sufficient data, and the remainder were assessed using the surface temperature criteria. One machine achieved a high performance, five a medium performance, four a low performance and one was identified as not suitable.

In summary, all nineteen machines that participated in the 2020 accreditation trial fully met the mandatory requirements of the trial (after additional testing for one device see section 6.3).

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

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Acknowledgements

The authors wish to thank the operators of the DPT devices for their co-operation in the accreditation process. The authors are also grateful to Dave Gershkoff who carried out the technical review of this report, to Chris Torkington, Darius Singfield, Jack Sealey and Nick Lindley for their support for the trial process and to Roy Jaques and Zhao Wang for their support in the processing of data.

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	4/2	2-way Segmented	Not provided	21/09/2020	29/07/2020
5	AECOM Ltd.	Dynatest HWD 8082 SN 050	Trailer	0/5	2-way Segmented	Not provided	21/09/2020	02/07/2020
10	AECOM Ltd.	Dynatest FWD 8002 SN 192	Trailer	6/3	2-way Segmented	Not provided	21/09/2020	07/08/2020
11	Pulse Surveying Ltd.	Dynatest FWD 8002 SN 187	Trailer	4/2	Solid	16/03/2020	02/09/2020	14/07/2020
13	AECOM Ltd.	Dynatest HWD 8082 SN 029	Trailer	0/5	Solid	Not provided	21/09/2020	16/09/2020
15	CET Infrastructure	Dynatest FWD 8002 SN 203	Trailer	5/2	2-way Segmented	16/09/2020	16/09/2020	16/09/2020
16	PTS	Dynatest FWD 8002 SN 214	Trailer	4/2	2-way Segmented	18/09/2020	18/09/2020	Aug 2020
28	Pulse Surveying Ltd.	Dynatest FWD 8002 SN 271	Trailer	4/2	Solid	17/03/2020	02/09/2020	17/07/2020
32	PTS	Dynatest HWD 8082 SN 069	Trailer	5/2	Solid	18/09/2020	18/09/2020	Aug 2020
33	PTS	Dynatest HWD 8082 SN 070	Trailer	5/2	Solid	18/09/2020	18/09/2020	Aug 2020

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
34	PTS	Dynatest HWD 8082 SN 108	Trailer	5/2	4-way Segmented	18/09/2020	18/09/2020	Sept 2020
39	TRL	Dynatest FWD 8002 SN 388	Trailer	6/3	2-way Segmented	27/08/2020	21/09/2020	08/06/2020
45	Atlas Geophysical	Grontmij Carlbro PRI2100 0903-088	Trailer	5/4	Solid	28/08/2020	28/08/2020	28/08/2020
47	PMS Ltd.	Dynatest FWD 8002 SN 452	Trailer	4/2	4-way Segmented	31/08/2020	31/08/2020	31/08/2020
48	Balfour Beatty	Dynatest FWD 8002 SN 424	Trailer	4/2	4-way Segmented	20/01/2020	20/01/2020	20/01/2020
50	SOCOTEC	RINCENT HeavyDyn HVY-101A	Trailer	10/4	Solid	14/09/2020	21/09/2020	08/10/2019
51	James Fisher Testing	Grontmij FWD PRI2500 0415-490	Trailer	3/4	4-way Segmented	28/07/2020	Not provided	Not provided
52	James Fisher Testing	Dynatest FFWD 8012 SN 057	Trailer	4/2	4-way Segmented	27/08/2020	27/08/2020	27/08/2020
53	Dynatest	Dynatest FWD 8002 SN 098	Trailer	4/2	4-way Segmented	10/09/2020	10/09/2020	10/09/2020

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 Assessment criteria

The accreditation trial criteria are specified in "Accreditation and Quality Assurance of Dynamic Plate Test Survey Devices" (TRL, 2020). The accreditation document is a live document (i.e. is subject to change) and the September 2020 version of the document was used for the trial. The relevant sections of the document are reproduced verbatim below in blue text (section D.1 and D.2). Note that the appendices referred to in section D.1 and D.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 positional 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.

D.1 Mandatory Trial criteria from the Accreditation and QA document

E4.2 Repeatability testing – Mandatory Requirement

E4.2.1 Repeatability testing shall 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 shall use a test procedure typical of general usage on the network. The test procedure shall 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) shall 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 (sometimes referred to as "seek" mode). This functionality shall not be used for the repeatability testing.

E4.2.4 The following shall 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 shall 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 to have failed the Repeatability criteria.

E4.2.6 The valid Repeatability data shall be collected and the Equipment shall 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 shall 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 For the Reproducibility test the 100mm pavement temperature should 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. Additional test sets may then need to be undertaken in order to obtain the required amount of Survey Data within the required temperature range.

E4.3.3 Reproducibility testing shall use a test procedure typical of general usage on the network. The test procedure shall 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) shall 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 shall be calculated by the Auditor for each test set. The Equipment shall 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 shall 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)

D.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 – direct measurement method

E5.3.1 If undertaking this test, the Contractor will be required to collect at least eight measurements at 100mm depth during the course of the test laps. These probes are required to provide results with a resolution equal to or better than 0.1˚C. Therefore if the probe does not then it will be identified as "Not suitable" regardless of the performance seen for the measurements (with a note identifying the reason for the performance given). The criteria for the direct measurement method are given in Table 5.

Table 5 - Acceptance Criteria for direct measurement method

Performance	Criteria
High	≥80% of the data is within 1.0°C of the Reference Data
Medium	≥60% of the data is within 1.0°C of the Reference Data
Low	≥25% of the data is within 1.0°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 – Contactless measurement

E5.4.1 If undertaking this test the Contractor shall be required to collect at least eight measurements of the pavement surface at defined points (specified by the Auditor) during the course of the test laps. These sensors are required to provide results with a resolution equal to or better than 0.1˚C. Therefore if the sensor does not then it will be identified as "Not suitable" regardless of the performance seen for the measurements (with a note identifying the reason for the performance given). The criteria for the assessment of 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 1.0°C of the Reference Data
Medium	≥60% of the data is within 1.0°C of the Reference Data
Low	≥25% of the data is within 1.0°C of the Reference Data
Not suitable	Otherwise

E5.4.2 In addition to providing the surface temperatures, the Contractor shall provide the predicted temperature at 100mm depth using this data. The Auditor may allow Contractors to provide these predicted temperatures after the trial to allow for processing time. To aid this calculation the Auditor should provide, or identify a suitable location for air temperature data for the previous day for the site. The Auditor shall confirm on the Accreditation Certificate whether the calculations have been accurately calculated.

Appendix E 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).

E.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	681.8	0.2%	70	61	56	50	42	35	24	0.4	0.7	0.7	1.0	0.3	0.2	0.4
	5	664.6	0.4%	510	406	255	151	89	55	32	2.7	0.7	0.4	1.1	0.3	0.3	0.2
	8	672.1	0.4%	246	216	172	131	95	68	34	0.3	0.5	0.5	0.5	0.3	0.5	0.4
	13	672.4	0.4%	131	115	104	83	69	54	37	1.4	0.2	**2.7**	0.5	1.3	0.6	1.3
2	2	673.3	0.4%	75	63	56	49	42	35	24	0.3	0.2	0.3	0.3	0.1	0.3	0.2
	5	657.0	0.2%	541	422	265	156	89	53	32	2.9	0.4	0.3	0.3	0.3	0.4	0.2
	8	664.6	0.4%	249	220	176	132	96	68	34	2.3	0.4	0.9	0.3	0.7	0.2	0.3
	13	664.6	0.4%	125	111	97	85	66	51	33	**2.3**	1.2	0.2	0.9	0.3	0.2	0.3

E.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*	*726.7*	*0.6%*	*68*	*56*	*50*	*43*	*37*	*31*	*21*	*0.6*	*0.7*	*0.4*	*0.3*	*0.6*	*0.3*	*0.5*
	5	*711.4*	*0.6%*	*491*	*377*	*240*	*146*	*90*	*60*	*40*	*2.0*	*1.7*	*1.3*	*1.5*	*0.4*	*0.4*	*0.5*
	8	*715.8*	*0.3%*	*225*	*195*	*156*	*119*	*89*	*64*	*35*	*1.2*	*0.8*	*0.6*	*0.7*	*0.9*	*1.1*	*0.8*
	13	*700.8*	*0.6%*	*113*	*101*	*86*	*72*	*58*	*45*	*33*	*0.8*	*0.9*	*0.7*	*1.0*	*0.8*	*0.5*	*1.4*
2	*2*	*712.2*	*0.9%*	*69*	*57*	*51*	*44*	*38*	*32*	*23*	*1.0*	*0.9*	*0.4*	*1.1*	*1.1*	*0.5*	*0.2*
	5	*701.9*	*0.7%*	*519*	*392*	*246*	*149*	*89*	*60*	*40*	*3.5*	*2.5*	*1.9*	*1.2*	*0.8*	*0.7*	*0.5*
	8	*707.7*	*0.6%*	*230*	*200*	*160*	*121*	*90*	*64*	*35*	*1.2*	*1.6*	*1.2*	*1.0*	*0.8*	*0.7*	*0.6*
	13	*704.1*	*0.8%*	*115*	*103*	*89*	*74*	*60*	*47*	*34*	*1.0*	*0.9*	*0.6*	*0.7*	*0.8*	*0.4*	*0.3*

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
3	2	698.4	0.7%	68	58	50	45	38	33	21	0.8	1.0	0.6	0.7	0.5	0.6	0.6
	5	691.9	0.9%	475	376	248	158	97	65	37	3.7	2.8	2.2	1.3	1.1	1.1	0.9
	8	693.2	1.1%	226	197	162	124	92	67	35	2.4	**3.4**	1.6	1.5	1.3	0.9	1.1
	13	682.7	0.6%	122	109	93	77	62	50	43	0.6	0.6	0.5	0.8	0.5	0.3	0.7
4	2	703.3	0.2%	66	56	49	45	39	31	21	0.5	0.5	0.5	0.6	0.5	0.5	0.4
	5	672.1	1.1%	478	385	254	160	99	64	40	4.4	3.6	2.6	1.6	1.2	1.4	0.4
	8	679.6	1.2%	228	201	163	125	94	72	36	2.5	1.9	1.8	**2.1**	1.0	1.4	0.5
	13	684.1	0.7%	121	107	93	76	62	48	37	1.1	0.9	0.6	0.5	0.7	0.5	0.7

E.3 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	709.1	0.6%	68	61	54	47	41	33	23	0.5	0.2	0.5	0.4	0.2	0.2	0.4
	5	691.6	0.4%	509	394	249	148	88	56	34	2.0	0.5	0.4	0.9	1.4	1.6	1.0
	8	697.8	0.5%	235	212	168	127	93	67	35	0.8	0.3	0.3	0.2	0.1	0.2	0.2
	13	703.0	0.2%	127	116	97	82	68	54	37	0.8	0.7	0.2	0.3	0.5	0.3	0.3
2	2	707.4	0.5%	70	61	54	49	41	34	24	0.2	0.1	0.1	0.5	0.2	0.1	0.3
	5	688.0	0.6%	543	418	259	152	89	56	35	0.5	0.2	0.3	0.3	0.1	0.7	0.1
	8	696.6	0.4%	244	215	171	129	95	67	35	0.3	0.2	0.2	0.2	0.1	0.3	0.1
	13	704.7	0.5%	116	111	94	78	64	51	33	1.2	0.1	0.1	0.1	0.1	0.2	0.1

E.4 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	723.5	0.2%	78	65	57	50	43	34	26	0.2	0.6	0.3	0.3	0.1	0.4	0.7
	5	706.5	0.2%	566	424	262	149	86	57	32	1.1	0.6	0.3	0.4	0.1	0.3	0.3
	8	717.5	0.2%	255	220	175	131	96	69	38	0.3	0.3	0.3	0.3	0.2	0.3	0.4
	13	723.6	0.1%	130	113	95	84	67	55	34	0.3	0.2	0.5	0.2	0.1	0.3	0.1
2	2	721.8	0.2%	79	65	57	48	42	36	24	0.3	0.3	0.4	0.2	0.3	0.2	0.5
	5	698.8	0.2%	581	440	267	153	84	49	34	0.5	0.6	0.9	0.2	0.5	0.7	0.8
	8	709.6	0.1%	260	227	180	133	100	68	34	0.3	0.3	0.2	0.3	0.3	0.2	0.4
	13	711.5	0.2%	128	113	97	76	66	51	31	0.6	0.3	0.7	**2.2**	0.3	0.3	1.4

E.5 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*	*740.0*	*0.4%*	*69*	*58*	*52*	*46*	*39*	*32*	*21*	*1.7*	*1.2*	*1.7*	*1.3*	***2.2***	*1.4*	*1.0*
	5	*734.3*	*0.5%*	*498*	*392*	*250*	*152*	*92*	*60*	*33*	*2.2*	*2.5*	*2.1*	*1.8*	*1.7*	***2.5***	*1.7*
	8	*731.6*	*0.5%*	*230*	*206*	*167*	*126*	*94*	*64*	*33*	*1.2*	*2.1*	*1.9*	***2.9***	*1.5*	***3.1***	***3.3***
	13	*728.1*	*0.5%*	*117*	*106*	*91*	*74*	*60*	*47*	*30*	*1.5*	*1.2*	*1.9*	***2.5***	*1.4*	*1.4*	*1.7*
2	*2*	*724.7*	*0.2%*	*71*	*60*	*54*	*47*	*40*	*35*	*23*	*1.6*	*0.8*	*1.9*	***2.7***	*1.4*	***2.2***	*0.8*
	5	*722.3*	*0.2%*	*534*	*413*	*261*	*151*	*88*	*54*	*41*	*1.5*	*0.9*	*0.9*	*1.3*	*1.3*	***2.4***	*1.3*
	8	*722.4*	*0.3%*	*242*	*212*	*169*	*128*	*94*	*65*	*38*	*1.0*	*0.6*	*2.0*	*1.3*	*1.7*	*0.9*	*1.4*
	13	*720.7*	*0.3%*	*116*	*102*	*84*	*72*	*58*	*45*	*27*	*1.5*	*0.7*	***2.1***	*0.9*	*1.3*	*1.6*	*1.5*
3	2	729.5	0.4%	69	57	51	45	39	33	23	0.5	0.4	0.2	0.1	0.2	0.3	0.5
	5	714.0	0.2%	524	409	257	151	89	56	36	0.4	0.9	0.6	0.3	0.6	0.3	0.3
	8	717.4	0.2%	240	213	169	128	94	64	33	0.9	0.5	0.4	0.2	0.3	0.6	0.1
	13	707.1	0.4%	121	110	90	77	62	49	40	0.7	0.4	1.0	0.3	1.0	0.7	0.4
4	2	725.5	0.4%	67	58	50	44	39	30	21	0.6	0.2	0.2	0.2	0.2	0.5	0.4
	5	717.2	0.2%	523	413	255	152	90	56	35	0.4	0.3	0.3	0.2	0.4	0.3	0.1
	8	697.7	0.4%	245	216	163	129	94	67	33	0.4	0.3	1.2	0.3	0.2	0.7	0.3
	13	693.2	0.1%	123	110	94	77	62	51	39	0.3	0.2	0.2	0.1	0.1	0.5	0.3

E.6 Machine 15 (laps 1 and 2 had incorrect number of drops and is not shown)

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
3	*2*	*773.8*	*0.9%*	*74*	*64*	*55*	*48*	*42*	*35*	*24*	*0.5*	*0.9*	*0.6*	*0.5*	*0.5*	*0.5*	*0.2*
	5	*748.5*	*0.9%*	*592*	*447*	*274*	*158*	*90*	*54*	*35*	***5.7***	*3.8*	***4.1***	*2.1*	*0.8*	*1.6*	*0.4*
	8	*764.1*	*0.6%*	*265*	*227*	*182*	*135*	*97*	*68*	*36*	*1.9*	*2.0*	*1.3*	*1.0*	*0.7*	*0.5*	*0.4*
	13	*766.6*	*0.8%*	*142*	*125*	*110*	*90*	*77*	*64*	*51*	*1.2*	*1.0*	*0.7*	*1.1*	*0.8*	*0.6*	*0.5*
4	2	707.6	1.2%	78	64	57	50	43	36	24	0.7	0.4	0.4	0.4	0.4	0.9	**2.1**
	5	707.6	0.8%	569	435	267	155	88	52	35	2.6	2.4	1.1	1.2	1.3	0.3	1.1
	8	708.0	1.0%	259	224	178	133	96	66	36	1.3	1.2	1.0	0.8	0.7	0.7	0.3
	13	705.9	1.0%	141	126	112	92	77	64	52	0.9	0.9	0.6	0.5	0.4	0.4	0.7
5	2	707.1	0.9%	76	65	57	50	43	36	24	0.7	0.7	0.4	0.4	0.4	0.4	0.4
	5	707.2	1.6%	581	445	272	157	89	53	34	4.8	3.8	2.5	1.2	1.9	0.6	1.3
	8	707.1	0.9%	266	230	183	137	98	68	35	1.8	1.6	1.2	1.0	0.6	0.7	0.5
	13	707.3	0.8%	129	118	101	85	69	55	41	1.1	0.7	0.6	0.7	0.5	0.7	0.3

E.7 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	717.2	0.3%	84	63	56	50	44	35	25	1.6	0.2	0.3	0.6	0.7	0.2	1.2
	5	698.7	0.2%	558	407	253	148	87	54	32	1.2	0.5	0.3	0.3	0.5	0.2	0.3
	8	709.8	0.2%	254	213	171	128	95	66	35	1.1	0.2	0.5	0.2	0.8	0.4	0.2
	13	712.8	0.3%	128	111	95	79	63	49	31	0.9	0.3	0.2	0.3	0.3	0.3	0.3
2	2	717.7	0.3%	82	65	59	50	43	35	27	0.6	0.2	0.2	0.5	0.3	0.3	1.7
	5	697.3	0.2%	595	422	257	149	85	50	32	0.9	0.4	0.3	0.3	0.5	0.1	0.4
	8	708.5	0.2%	260	221	177	131	96	67	35	0.7	0.3	0.4	0.3	0.3	0.2	0.1
	13	710.8	0.3%	123	110	94	78	63	50	32	0.4	0.2	0.2	0.5	0.5	0.2	0.1

E.8 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	730.1	0.1%	79	58	56	50	43	35	24	0.2	0.4	0.3	0.3	0.1	0.2	0.4
	5	718.0	0.1%	565	418	251	149	85	51	32	1.0	0.6	0.4	0.4	0.2	0.3	0.2
	8	724.3	0.1%	254	216	169	134	97	64	34	0.4	0.3	0.7	0.3	0.3	0.4	0.9
	13	730.9	0.2%	127	110	93	82	66	53	33	0.2	1.0	1.3	0.5	0.1	0.2	0.4
2	2	731.9	0.1%	76	62	55	50	44	35	21	0.1	0.2	0.1	0.3	0.2	0.7	0.3
	5	715.7	0.1%	585	431	258	149	83	52	34	1.4	0.6	0.4	0.6	0.3	0.2	0.3
	8	723.3	0.2%	258	216	179	132	97	66	35	0.3	0.5	0.8	0.7	0.6	0.3	0.4
	13	731.2	0.1%	131	109	96	79	67	46	31	0.2	0.3	0.2	0.4	0.4	1.1	0.2

E.9 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	742.3	0.2%	73	58	51	46	40	32	22	0.1	0.2	0.1	0.1	0.3	0.1	0.4
	5	734.2	0.2%	503	380	233	148	88	56	37	0.3	0.5	0.4	0.1	0.3	0.3	0.2
	8	728.8	0.9%	239	201	159	123	89	64	35	0.3	0.2	0.3	0.3	0.3	0.1	0.5
	13	735.9	0.4%	120	106	90	76	60	47	32	0.5	0.3	0.3	0.2	0.4	0.4	0.7
2	2	743.6	0.1%	75	59	51	46	39	33	22	0.1	0.2	0.4	0.2	0.1	0.2	0.2
	5	725.2	0.2%	547	379	232	147	85	56	37	0.3	0.7	0.6	0.4	0.4	0.3	0.6
	8	735.0	0.4%	239	204	159	123	88	64	34	0.3	0.7	0.3	0.7	0.5	0.3	0.6
	13	741.4	0.2%	124	108	91	77	61	49	33	0.2	0.2	0.2	0.1	0.2	0.5	0.2

E.10 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	729.3	0.3%	69	57	51	44	38	32	21	0.2	0.4	0.3	0.3	0.1	0.8	0.4
	5	707.1	0.4%	524	380	238	150	91	59	39	1.4	0.7	0.7	0.8	0.7	0.2	0.6
	8	702.4	0.2%	234	200	159	122	88	65	35	0.9	0.8	0.6	0.3	0.7	0.3	0.5
	13	702.1	0.3%	119	106	90	74	58	45	31	0.3	0.5	0.6	0.2	0.3	0.8	0.7
2	2	733.8	0.2%	68	57	52	46	38	32	23	1.4	0.8	0.6	0.6	0.3	1.0	1.1
	5	703.3	0.3%	556	406	251	155	85	59	41	1.1	1.1	0.9	0.7	0.8	0.7	0.9
	8	714.0	0.2%	238	201	161	123	88	64	35	0.5	0.8	0.5	0.4	0.4	1.0	0.5
	13	713.9	0.2%	113	101	88	73	57	45	29	0.6	0.8	0.6	0.1	0.3	0.4	0.2
3	2	**787.9**	0.4%	72	59	52	46	39	33	21	0.1	0.3	0.2	0.3	0.2	0.5	0.4
	5	735.2	1.1%	541	429	259	158	93	62	43	0.3	0.8	0.6	0.8	0.1	0.1	0.7
	8	753.9	0.3%	248	214	170	130	93	67	36	0.4	0.6	0.5	0.4	0.4	0.3	0.7
	13	675.2	0.7%	124	110	94	79	63	52	48	0.4	0.4	0.3	0.2	0.3	0.2	0.2
4	2	696.8	0.4%	72	59	52	46	37	33	22	0.9	0.4	0.3	0.3	0.6	0.5	0.2
	5	665.7	0.4%	567	416	255	159	91	62	41	0.8	1.3	0.7	0.4	0.8	0.6	0.7
	8	664.0	0.1%	250	212	167	127	91	66	35	1.4	0.3	0.3	0.2	0.4	0.1	0.4
	13	689.7	0.4%	127	113	96	81	64	52	45	0.6	0.2	0.2	0.2	0.2	0.2	0.3
5	2	687.2	0.3%	72	59	53	46	39	33	22	0.6	0.5	0.2	0.5	0.4	0.2	0.9
	5	670.6	0.3%	576	421	259	160	92	64	40	0.6	0.5	0.5	0.5	0.5	0.3	0.9
	8	675.4	0.2%	251	214	169	129	93	67	36	0.8	0.2	0.4	0.2	0.3	0.4	0.4
	13	688.9	0.3%	126	113	96	80	63	50	43	0.2	0.3	0.2	0.2	0.1	0.2	0.3
6	2	711.9	0.8%	67	57	52	46	38	32	22	0.5	0.3	0.4	0.4	0.4	0.4	0.5
	5	682.7	0.8%	487	370	242	156	97	66	40	0.8	0.7	1.1	0.4	1.0	1.1	0.4
	8	666.2	0.4%	227	197	158	123	90	66	35	0.4	0.3	0.2	0.2	0.3	0.1	0.5
	13	660.1	0.6%	117	105	90	75	60	47	38	0.2	0.2	0.3	0.2	0.2	0.2	0.2
7	2	774.8	0.2%	70	58	52	45	39	33	22	0.3	0.4	0.5	0.2	0.1	0.3	0.5
	5	770.7	0.3%	487	393	258	164	99	67	40	0.4	0.3	0.2	0.1	0.1	0.2	0.5
	8	769.6	0.1%	237	206	165	128	93	68	36	0.2	0.6	0.2	0.3	0.4	0.3	0.4
	13	749.2	0.2%	133	117	100	83	64	50	37	0.2	0.2	0.1	0.1	0.1	0.2	0.2

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
8	2	769.0	0.2%	70	59	52	46	39	33	22	0.2	0.2	0.2	0.1	0.2	0.2	0.2
	5	747.3	0.1%	514	390	249	159	97	65	40	0.8	0.6	0.6	0.3	0.4	0.2	0.1
	8	759.7	0.2%	239	208	166	129	93	68	36	0.4	0.2	0.2	0.2	0.3	0.2	0.5
	13	754.3	0.6%	128	115	97	81	64	51	43	0.3	0.2	0.1	0.1	0.2	0.2	0.2

E.11 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
1	*2*	*68*	*56*	*50*	*44*	*37*	*31*	*21*	*0.2*	*0.2*	*0.4*	*0.5*	*0.9*	*0.6*	*0.8*	*68*	*56*
	5	*486*	*373*	*244*	*148*	*84*	*56*	*34*	*0.7*	*0.5*	*0.4*	*0.4*	*1.2*	*0.5*	*0.3*	*486*	*373*
	8	*226*	*197*	*160*	*120*	*89*	*63*	*34*	*0.4*	*0.4*	*0.4*	*0.3*	*0.4*	*0.2*	*0.7*	*226*	*197*
	13	*119*	*107*	*91*	*76*	*60*	*50*	*34*	*0.9*	*1.1*	*1.5*	*0.2*	*0.4*	*1.2*	*1.0*	*119*	*107*
2	*2*	*68*	*56*	*50*	*44*	*36*	*31*	*20*	*0.2*	*0.2*	*0.3*	*0.4*	*1.0*	*0.2*	*0.2*	*68*	*56*
	5	*502*	*378*	*246*	*145*	*83*	*55*	*38*	*0.5*	*0.4*	*0.3*	*0.7*	*0.3*	*0.4*	*1.2*	*502*	*378*
	8	*227*	*200*	*161*	*121*	*87*	*63*	*32*	*1.8*	*0.4*	*0.8*	*0.3*	*0.3*	*0.2*	*0.7*	*227*	*200*
	13	*117*	*105*	*90*	*74*	*59*	*46*	*30*	*1.2*	*0.4*	*0.3*	*0.4*	*0.4*	*0.3*	*1.2*	*117*	*105*
3	*2*	*70*	*57*	*51*	*45*	*37*	*32*	*22*	*0.1*	*0.2*	*0.3*	*0.2*	*0.2*	*0.2*	*0.2*	*70*	*57*
	5	*544*	*409*	*258*	*151*	*84*	*64*	*43*	*0.5*	*1.3*	*0.9*	*0.5*	*0.3*	*0.5*	*0.6*	*544*	*409*
	8	*241*	*210*	*168*	*126*	*89*	*64*	*34*	*0.4*	*0.6*	*1.1*	*0.8*	*0.5*	*0.8*	*0.4*	*241*	*210*
	13	*124*	*112*	*95*	*79*	*62*	*52*	*44*	*0.7*	*0.6*	*0.3*	*0.6*	*0.5*	*0.2*	*0.6*	*124*	*112*
4	*2*	*69*	*57*	*52*	*45*	*38*	*31*	*21*	*0.4*	*0.1*	*0.2*	*0.4*	*0.3*	*0.3*	*0.4*	*69*	*57*
	5	*543*	*416*	*262*	*156*	*88*	*57*	*37*	*0.6*	*0.4*	*0.5*	*0.3*	*0.2*	*0.8*	*0.3*	*543*	*416*
	8	*243*	*211*	*169*	*128*	*90*	*65*	*32*	*0.7*	*0.3*	*0.4*	*0.4*	*0.5*	*0.6*	*0.6*	*243*	*211*
	13	*126*	*112*	*97*	*80*	*63*	*52*	*43*	*0.5*	*0.4*	*0.5*	*0.6*	*0.7*	*0.8*	*0.3*	*126*	*112*
5	2	69	57	51	45	38	32	22	0.2	0.1	0.3	0.4	0.3	0.2	0.3	69	57
	5	502	394	259	155	88	61	36	0.6	1.2	0.4	0.7	0.6	0.2	0.4	502	394
	8	231	203	165	126	91	65	34	0.8	0.6	0.8	1.1	1.0	0.5	1.2	231	203
	13	120	107	91	77	61	49	31	0.3	0.3	1.0	0.2	0.3	0.3	0.8	120	107

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
6	2	68	57	52	45	39	32	23	0.2	0.1	0.2	0.2	0.7	0.1	0.8	68	57
	5	502	391	258	155	88	58	36	0.5	0.6	0.4	0.6	0.4	0.4	0.5	502	391
	8	236	204	167	126	90	67	32	0.9	0.5	0.6	0.8	0.4	0.4	1.3	236	204
	13	122	109	95	78	62	50	34	0.3	0.2	0.4	0.8	0.7	0.2	0.3	122	109

E.12 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	698.6	0.2%	73	62	55	49	42	35	24	0.4	0.3	0.3	0.3	0.3	0.2	0.2
	5	672.7	0.4%	531	407	253	151	89	53	31	0.7	0.9	0.8	0.9	1.0	1.7	0.2
	8	681.3	0.2%	248	215	172	131	96	68	36	0.2	0.4	0.5	0.2	0.2	0.2	0.3
	13	697.2	0.6%	123	111	94	79	64	51	33	1.4	0.1	0.3	0.1	0.1	0.3	0.2
2	2	691.5	0.4%	75	62	56	50	43	35	24	0.3	0.2	0.2	0.3	0.2	0.6	0.5
	5	669.9	0.3%	562	429	261	153	89	50	33	1.1	0.8	0.4	0.4	0.1	0.9	0.2
	8	685.7	0.3%	251	218	175	133	96	69	35	0.5	0.3	0.6	0.4	0.4	0.3	0.3
	13	682.8	0.3%	130	115	96	80	66	51	33	0.9	**2.3**	1.0	1.5	0.2	2.0	0.9

E.13 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	700.6	0.2%	77	64	57	50	43	36	25	0.6	0.6	0.6	0.6	0.6	0.1	0.1
	5	696.8	0.3%	524	407	257	154	90	53	29	1.7	1.2	0.8	0.7	0.7	0.5	0.5
	8	691.0	0.3%	251	219	175	132	95	68	34	0.9	0.7	0.5	0.7	0.3	0.2	0.5
	13	698.5	0.3%	135	117	99	82	67	55	34	0.8	0.3	0.3	0.2	0.2	0.2	0.1
2	2	713.9	0.3%	81	65	57	50	44	37	25	0.2	0.5	0.1	0.1	0.1	0.5	0.5
	5	710.1	0.2%	542	429	266	155	87	50	31	1.8	1.2	0.8	0.5	0.4	0.5	0.1
	8	702.1	0.2%	256	223	178	134	97	69	34	0.7	0.6	0.6	0.3	0.5	0.6	0.4
	13	689.7	0.4%	129	115	97	80	66	54	34	0.5	0.4	0.5	0.3	0.6	0.2	0.1
3	2	696.9	0.3%	81	66	58	52	43	37	23	0.4	0.3	0.2	0.2	0.4	0.1	0.1
	5	705.5	0.2%	545	435	273	161	90	54	28	1.5	1.5	1.1	0.6	0.6	0.7	0.5
	8	696.3	0.2%	266	230	183	138	98	69	34	0.2	0.3	0.3	0.4	0.1	0.1	0.1
	13	680.4	0.1%	147	128	108	90	75	62	46	0.2	0.2	0.2	0.1	0.5	0.4	0.3
4	2	700.7	0.2%	79	66	58	51	43	36	24	0.1	0.1	0.1	0.1	0.4	0.3	0.0
	5	702.8	0.1%	564	439	273	160	91	53	29	1.4	0.9	0.4	0.5	0.5	0.0	0.4
	8	697.3	0.2%	266	230	184	139	99	69	32	0.3	0.3	0.4	0.4	0.4	0.1	0.1
	13	681.5	0.2%	145	127	107	89	73	61	44	0.3	0.2	0.2	0.2	0.1	0.5	0.3

E.14 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	699.0	0.1%	78	65	58	50	43	36	24	0.1	0.2	0.2	0.2	0.1	0.1	0.1
	5	687.3	0.1%	550	418	256	147	84	50	29	1.0	0.3	0.3	0.2	0.3	0.4	0.2
	8	692.1	0.1%	254	219	175	132	95	68	34	0.3	0.2	0.2	0.1	0.2	0.1	0.1
	13	691.9	0.1%	127	113	96	80	64	51	30	0.3	0.2	0.1	0.1	0.2	0.2	0.3
2	2	696.1	0.1%	78	65	58	51	44	37	25	0.2	0.2	0.1	0.1	0.1	0.1	0.2
	5	683.2	0.1%	564	430	261	148	82	48	29	0.7	0.4	0.4	0.3	0.3	0.3	0.5
	8	688.7	0.1%	258	224	178	134	97	68	34	0.3	0.1	0.1	0.2	0.1	0.1	0.1
	13	686.8	0.2%	125	112	99	81	65	52	30	0.2	0.9	0.8	0.5	0.5	0.2	0.3

E.15 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	723.1	0.2%	75	63	57	49	42	36	24	1.6	0.3	0.4	0.3	0.3	0.3	0.3
	5	710.2	0.2%	511	400	250	148	86	54	32	0.9	0.6	0.3	0.2	0.3	0.3	0.1
	8	713.9	0.2%	247	215	172	130	95	68	35	0.4	0.4	0.2	0.4	0.4	0.5	0.1
	13	717.7	0.2%	131	117	100	83	67	54	35	1.1	0.9	1.1	0.6	0.6	0.7	0.6
2	2	716.1	0.2%	77	63	56	50	42	36	24	0.5	0.8	0.7	0.5	0.3	0.1	0.6
	5	702.8	0.2%	582	434	264	150	82	55	33	2.1	0.6	0.3	0.3	0.4	0.4	0.5
	8	708.4	0.1%	255	222	178	135	98	68	34	0.4	0.3	0.4	1.1	0.5	0.4	0.3
	13	708.5	0.1%	128	114	97	82	66	53	31	0.5	0.5	0.1	0.6	0.1	0.3	0.0

E.16 Machine 50 (laps 1 and 2 had incorrect number of drops and is not shown)

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
3	2	707.4	0.1%	67	57	50	45	39	31	21	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	5	696.3	0.1%	461	373	244	153	95	57	31	0.9	0.9	0.4	0.2	0.3	0.2	0.3
	8	702.1	0.1%	221	198	159	124	92	62	34	0.2	0.5	0.2	0.1	0.2	0.2	0.2
	13	702.4	0.2%	122	111	95	79	65	49	38	0.2	0.2	0.1	0.1	0.1	0.2	0.2
4	2	703.6	0.2%	67	57	50	45	39	31	22	0.1	0.1	0.1	0.1	0.2	0.1	0.2
	5	688.5	0.2%	461	374	244	153	95	57	31	1.1	1.0	0.4	0.3	0.2	0.4	0.2
	8	693.7	0.4%	222	198	160	125	93	63	34	0.5	0.4	0.2	0.1	0.2	0.2	0.2
	13	693.7	0.2%	119	109	92	78	63	48	35	0.3	0.2	0.1	0.2	0.1	0.2	0.2

E.17 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*	*713.5*	*1.1%*	*73*	*65*	*56*	*50*	*41*	*33*	*22*	*0.5*	*0.6*	*0.4*	***2.1***	*0.9*	*0.7*	*1.4*
	5	*717.3*	*1.0%*	*521*	*403*	*250*	*154*	*89*	*53*	*32*	*1.7*	*0.5*	*0.5*	*0.3*	*0.5*	*0.2*	*0.2*
	8	*711.0*	*0.9%*	*243*	*215*	*171*	*131*	*91*	*63*	*32*	*0.3*	*0.4*	*0.4*	*1.0*	*0.9*	*1.2*	***5.9***
	13	*692.4*	*0.7%*	*126*	*116*	*95*	*81*	*65*	*51*	*32*	*0.6*	***2.2***	*1.0*	*0.4*	*0.3*	*1.6*	***2.9***
2	*2*	*703.6*	*1.1%*	*78*	*70*	*54*	*48*	*42*	*32*	*26*	*1.3*	*0.5*	*0.7*	*0.6*	***2.9***	*0.7*	***2.6***
	5	*706.0*	*0.7%*	*566*	*423*	*259*	*154*	*88*	*51*	*32*	*1.3*	*0.8*	*0.5*	*0.5*	*1.2*	*0.2*	*0.2*
	8	*701.3*	*0.8%*	*259*	*229*	*179*	*136*	*98*	*67*	*35*	*1.1*	*1.0*	*0.5*	*0.4*	*1.0*	*0.3*	*0.2*
	13	*691.1*	*0.8%*	*129*	*119*	*100*	*83*	*67*	*51*	*32*	*1.2*	*0.7*	*0.7*	*0.3*	*0.3*	*0.4*	*0.2*
3	2	705.7	0.8%	76	65	57	50	43	34	23	0.4	0.2	0.3	0.2	0.1	0.1	0.1
	5	707.6	0.5%	553	425	256	155	89	52	32	1.4	1.0	0.4	0.4	0.4	0.3	0.2
	8	709.2	1.1%	253	220	173	134	96	66	33	0.9	0.9	0.6	0.3	0.3	0.4	0.2
	13	705.9	0.7%	132	118	99	83	66	51	37	0.7	0.2	0.3	0.2	0.2	0.4	0.2
4	2	705.3	0.6%	73	64	56	49	42	33	22	0.3	0.2	0.2	0.2	0.2	0.2	0.1
	5	706.4	0.8%	537	411	252	153	88	51	32	2.9	0.8	0.6	0.5	0.6	0.3	1.0
	8	707.0	0.9%	249	219	172	132	95	65	32	1.3	0.5	0.3	0.3	0.2	0.3	0.4
	13	703.8	1.0%	125	114	96	81	65	53	41	0.6	0.1	0.2	0.1	0.2	0.2	0.1

E.18 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	706.8	0.5%	77	64	57	50	43	35	24	0.6	0.2	0.3	0.2	0.1	0.1	0.1
	5	707.4	0.9%	558	413	257	152	88	54	33	0.9	0.3	0.3	0.1	0.2	0.2	0.6
	8	706.0	0.4%	254	221	178	135	97	68	35	0.4	0.3	0.2	0.3	0.4	0.2	0.3
	13	706.7	0.3%	132	119	101	84	68	54	34	0.5	0.8	0.2	0.3	0.2	0.5	0.4
2	2	706.9	1.0%	77	64	57	50	43	36	24	0.5	0.2	0.2	0.4	0.2	0.4	0.2
	5	706.8	0.8%	578	441	269	154	86	52	34	0.6	0.6	0.6	0.3	0.2	0.2	0.2
	8	706.0	0.6%	257	222	179	135	97	69	35	0.5	0.2	0.1	0.3	0.1	0.3	0.5
	13	706.9	0.4%	126	112	97	80	65	51	32	0.7	0.3	0.2	0.2	0.1	1.0	0.2

E.19 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	725.0	0.3%	74	61	54	48	41	34	23	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	5	707.1	0.2%	545	402	252	147	85	52	35	0.5	0.3	0.2	0.2	0.2	0.2	0.3
	8	711.6	0.3%	244	214	171	129	93	66	34	0.2	0.2	0.1	0.1	0.1	0.2	0.2
	13	709.4	0.3%	122	112	95	80	65	52	33	0.5	0.3	0.7	0.2	0.3	0.2	0.2
2	2	726.4	0.4%	73	61	54	48	41	34	23	0.3	0.4	0.5	0.2	0.2	0.4	0.5
	5	708.6	0.3%	555	422	263	154	89	55	37	0.7	0.4	0.2	0.5	0.4	0.6	0.5
	8	716.6	0.2%	253	219	175	132	95	66	35	0.3	0.2	0.4	0.5	0.3	0.4	0.1
	13	719.5	0.2%	143	127	110	93	76	64	54	0.3	0.3	0.6	0.4	0.4	0.1	0.3

Appendix F 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). To clearly distinguish between the two test days, the first lap on day 3 was labelled as 21.

F.1 All Reproducibility trial data

Table F.1: Machine 02 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	*1.018*	*0.992*	*0.985*	*0.980*	*0.992*	*0.995*	*0.991*	*0.993*	*0.016*	*0.012*	*0.011*	*0.018*	*0.015*	*0.019*	*0.023*	*0.016*
2	*N*	*1.027*	*1.003*	*0.991*	*0.988*	*0.993*	*0.992*	*0.990*	*0.998*	*0.022*	*0.009*	*0.014*	*0.015*	*0.022*	*0.018*	*0.045*	*0.021*
3	*N*	*1.002*	*0.985*	*0.980*	*0.982*	*0.992*	*0.995*	*1.019*	*0.993*	*0.020*	*0.009*	*0.011*	*0.007*	*0.007*	*0.023*	*0.030*	*0.015*
21	*N*	*1.023*	*0.989*	*0.987*	*0.994*	*0.995*	*1.003*	*1.001*	*0.999*	*0.026*	*0.009*	*0.015*	*0.010*	*0.011*	*0.009*	*0.023*	*0.015*
22	Y	1.018	0.992	0.987	0.988	0.998	1.000	0.994	0.997	0.021	0.010	0.011	0.011	0.009	0.009	0.028	0.014
23	Y	1.013	0.993	0.985	0.988	0.990	1.010	1.010	0.999	0.013	0.007	0.016	0.018	0.009	0.013	0.053	0.019
24	*N*	*1.015*	*0.985*	*0.983*	*0.986*	*0.984*	*0.995*	*0.999*	*0.993*	*0.018*	*0.007*	*0.013*	*0.010*	*0.009*	*0.014*	*0.015*	*0.012*
25	*N*	*1.018*	*0.995*	*0.986*	*0.986*	*0.994*	*1.014*	*0.995*	*0.998*	*0.016*	*0.005*	*0.013*	*0.019*	*0.009*	*0.015*	*0.039*	*0.017*
26	*N*	*1.007*	*0.983*	*0.984*	*0.986*	*0.987*	*0.995*	*0.999*	*0.992*	*0.017*	*0.010*	*0.013*	*0.009*	*0.013*	*0.011*	*0.033*	*0.015*

Table F.2: Machine 05 - All trial data during the main trial day (all laps - full dataset)

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
1	N	1.083	1.084	1.078	1.078	1.052	1.033	0.996	**1.058**	0.030	0.024	0.026	0.036	0.050	**0.073**	0.051	0.041
2	N	1.045	1.048	1.046	1.042	1.025	1.016	0.952	1.025	0.024	0.028	0.029	0.039	0.044	0.058	**0.082**	0.043
3	N	1.060	1.059	1.056	1.051	1.031	1.015	0.988	1.037	0.029	0.027	0.032	0.043	0.053	**0.070**	**0.088**	0.049
21	N	1.018	1.023	1.018	1.020	1.006	0.978	0.971	1.005	0.018	0.025	0.029	0.029	0.043	0.053	0.066	0.037
22	Y	1.016	1.026	1.019	1.016	1.012	0.979	0.977	1.006	0.023	0.026	0.028	0.035	0.043	0.064	**0.084**	0.043
23	Y	1.030	1.026	1.017	1.017	1.005	0.978	0.979	1.007	0.029	0.033	0.035	0.046	0.048	0.069	**0.106**	**0.052**
24	N	1.025	1.023	1.020	1.019	1.004	0.986	0.968	1.006	0.024	0.021	0.023	0.031	0.041	0.047	**0.089**	0.039
25	N	1.029	1.026	1.020	1.021	1.006	0.994	0.965	1.009	0.030	0.032	0.035	0.044	0.053	0.054	**0.099**	0.050
26	N	1.025	1.021	1.015	1.021	1.001	0.987	0.991	1.009	0.022	0.025	0.026	0.036	0.034	0.053	**0.087**	0.040

Table F.3: Machine 10 - All trial data during the main trial day (all laps - full dataset)

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
1	N	1.032	1.001	0.999	1.009	0.998	0.997	0.990	1.004	0.032	0.015	0.011	0.009	0.010	0.012	0.019	0.015
2	N	1.069	1.022	1.018	1.020	1.010	1.002	1.007	1.021	0.024	0.011	0.012	0.012	0.023	0.033	0.026	0.020
3	N	1.029	1.008	1.006	1.010	1.003	1.003	0.996	1.008	0.037	0.017	0.011	0.010	0.013	0.013	0.023	0.018
21	N	1.028	0.994	0.998	1.002	0.995	0.993	0.984	0.999	0.029	0.013	0.011	0.010	0.009	0.010	0.014	0.014
22	Y	1.013	0.996	0.999	1.000	0.997	0.992	0.995	0.999	0.023	0.011	0.010	0.009	0.008	0.010	0.011	0.012
23	Y	1.035	0.994	0.996	0.998	0.992	0.987	0.985	0.998	0.035	0.009	0.009	0.008	0.010	0.010	0.011	0.013
24	N	1.039	0.994	1.000	1.001	0.988	0.985	0.988	0.999	0.037	0.012	0.011	0.010	0.011	0.013	0.016	0.016
25	N	1.029	0.997	1.000	1.001	0.991	0.997	0.993	1.001	0.026	0.011	0.011	0.012	0.011	0.018	0.019	0.015
26	N	1.030	0.996	1.000	1.002	0.993	0.988	0.997	1.001	0.029	0.012	0.011	0.015	0.014	0.018	0.026	0.018

Table F.4: Machine 11 - All trial data during the main trial day (all laps - full dataset)

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
1	N	0.941	0.965	0.973	0.996	0.983	0.995	1.003	0.980	0.042	0.017	0.016	0.021	0.023	0.031	0.037	0.027
2	N	0.962	0.975	0.978	0.994	0.991	0.990	0.983	0.982	0.031	0.009	0.014	0.023	0.019	0.027	0.029	0.022
3	N	0.966	0.986	0.992	1.000	0.982	0.995	1.002	0.989	0.019	0.014	0.013	0.018	0.011	0.023	0.020	0.017
21	N	0.958	0.977	0.971	0.990	0.983	0.976	0.991	0.978	0.022	0.014	0.014	0.019	0.013	0.020	0.041	0.020
22	Y	0.971	0.980	0.979	0.990	0.981	0.977	0.986	0.980	0.021	0.018	0.029	0.013	0.025	0.028	0.025	0.023
23	Y	0.964	0.964	0.969	0.986	0.976	0.982	0.980	0.974	0.018	0.027	0.017	0.026	0.019	0.024	0.033	0.023
24	N	0.971	0.986	0.979	0.984	0.982	0.990	0.985	0.982	0.019	0.015	0.016	0.014	0.020	0.020	0.020	0.018
25	N	0.968	0.984	0.985	0.993	0.983	0.991	0.982	0.984	0.024	0.020	0.012	0.012	0.026	0.020	0.035	0.021
26	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F.5: Machine 13 - All trial data during the main trial day (all laps - full dataset)

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
1	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	N	1.085	1.054	1.038	1.041	1.022	1.036	1.022	1.042	0.023	0.015	0.020	0.029	0.037	0.048	0.051	0.032
3	N	1.082	1.053	1.042	1.046	1.025	1.023	1.028	1.043	0.040	0.027	0.034	0.033	0.030	0.054	**0.081**	0.043
21	N	1.047	1.048	1.050	1.048	1.034	1.037	1.017	1.040	0.016	0.018	0.023	0.024	0.026	0.038	0.026	0.024
22	Y	1.055	1.049	1.057	1.046	1.033	1.031	1.036	1.044	0.017	0.020	0.030	0.026	0.030	0.060	0.058	0.035
23	Y	1.053	1.051	1.048	1.049	1.039	1.035	1.052	1.047	0.019	0.023	0.029	0.028	0.036	0.033	0.041	0.030
24	N	1.052	1.051	1.049	1.043	1.026	1.030	0.993	1.035	0.029	0.024	0.027	0.029	0.033	0.040	0.045	0.033
25	N	1.059	1.052	1.051	1.049	1.022	1.031	1.004	1.038	0.023	0.018	0.024	0.027	0.038	0.031	0.055	0.031
26	N	1.064	1.046	1.042	1.039	1.020	1.042	1.013	1.038	0.016	0.013	0.020	0.022	0.025	0.040	0.035	0.025

Table F.6: Machine 15 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	*0.963*	*0.970*	*0.973*	*0.981*	*0.983*	*0.997*	*1.015*	*0.983*	*0.029*	*0.014*	*0.017*	*0.019*	*0.021*	*0.041*	*0.056*	*0.028*
2	*N*	*0.983*	*0.990*	*0.984*	*1.000*	*1.000*	*0.996*	*1.004*	*0.994*	*0.026*	*0.012*	*0.012*	*0.019*	*0.021*	*0.021*	*0.041*	*0.021*
3	*N*	*0.972*	*0.987*	*0.986*	*0.998*	*0.998*	*0.995*	*0.997*	*0.990*	*0.019*	*0.037*	*0.023*	*0.031*	*0.034*	*0.048*	*0.039*	*0.033*
21	*N*	*0.980*	*0.973*	*0.976*	*0.982*	*0.984*	*0.990*	*0.982*	*0.981*	*0.024*	*0.010*	*0.009*	*0.013*	*0.017*	*0.022*	*0.033*	*0.018*
22	Y	0.971	0.976	0.977	0.975	0.986	0.993	0.981	0.980	0.013	0.010	0.011	0.026	0.033	0.024	0.036	0.022
23	Y	0.974	0.975	0.977	0.982	0.983	0.986	0.985	0.980	0.015	0.014	0.018	0.021	0.021	0.030	0.043	0.023
24	*N*	*0.980*	*0.977*	*0.977*	*0.986*	*0.983*	*0.986*	*0.999*	*0.984*	*0.024*	*0.013*	*0.011*	*0.014*	*0.019*	*0.026*	*0.048*	*0.022*
25	*N*	*0.975*	*0.977*	*0.976*	*0.983*	*0.978*	*0.997*	*0.998*	*0.983*	*0.018*	*0.027*	*0.024*	*0.027*	*0.024*	*0.032*	*0.052*	*0.029*
26	*N*	*0.969*	*0.971*	*0.972*	*0.983*	*0.985*	*0.991*	*1.001*	*0.982*	*0.013*	*0.013*	*0.015*	*0.022*	*0.022*	*0.037*	*0.042*	*0.023*

Table F.7: Machine 16 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	*0.961*	*0.986*	*0.983*	*0.990*	*0.998*	*1.006*	*0.995*	*0.989*	*0.050*	*0.013*	*0.014*	*0.014*	*0.017*	*0.026*	*0.025*	*0.023*
2	*N*	*0.951*	*0.990*	*0.986*	*0.988*	*0.990*	*1.002*	*0.992*	*0.986*	*0.046*	*0.013*	*0.015*	*0.014*	*0.018*	*0.027*	*0.029*	*0.023*
3	*N*	*0.955*	*0.983*	*0.978*	*0.983*	*0.995*	*0.997*	*0.986*	*0.983*	*0.058*	*0.018*	*0.016*	*0.016*	*0.021*	*0.026*	*0.047*	*0.029*
21	*N*	*0.942*	*0.974*	*0.971*	*0.982*	*0.981*	*0.978*	*0.957*	*0.969*	*0.051*	*0.030*	*0.028*	*0.034*	*0.035*	*0.039*	*0.049*	*0.038*
22	Y	0.959	0.984	0.986	0.992	1.001	0.994	0.979	0.985	0.036	0.021	0.019	0.019	0.022	0.026	0.040	0.026
23	Y	0.956	0.989	0.988	0.994	0.994	0.997	0.982	0.986	0.029	0.013	0.009	0.012	0.012	0.028	0.024	0.018
24	*N*	*0.966*	*0.994*	*0.988*	*0.988*	*0.986*	*0.989*	*0.980*	*0.984*	*0.034*	*0.028*	*0.016*	*0.014*	*0.016*	*0.021*	*0.022*	*0.022*
25	*N*	*0.967*	*0.985*	*0.987*	*0.992*	*0.990*	*1.001*	*0.990*	*0.987*	*0.025*	*0.010*	*0.007*	*0.009*	*0.012*	*0.015*	*0.017*	*0.014*
26	*N*	*0.958*	*0.989*	*0.989*	*0.995*	*0.999*	*0.997*	*0.979*	*0.987*	*0.039*	*0.017*	*0.011*	*0.014*	*0.017*	*0.012*	*0.029*	*0.020*

Table F.8: Machine 28 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	*0.961*	*0.983*	*0.989*	*0.981*	*0.998*	*1.039*	*1.049*	*1.000*	*0.015*	*0.018*	*0.023*	*0.028*	*0.025*	*0.047*	*0.054*	*0.030*
2	*N*	*0.979*	*0.998*	*1.004*	*0.983*	*0.975*	*1.037*	*1.071*	*1.007*	*0.034*	*0.019*	*0.023*	*0.030*	*0.039*	*0.036*	*0.064*	*0.035*
3	*N*	*0.994*	*0.999*	*1.009*	*0.986*	*0.984*	*1.011*	*1.054*	*1.006*	*0.018*	*0.018*	*0.022*	*0.032*	*0.029*	*0.033*	*0.062*	*0.030*
21	*N*	*0.971*	*1.003*	*0.997*	*0.979*	*0.985*	*1.016*	*1.044*	*0.999*	*0.048*	*0.018*	*0.012*	*0.043*	*0.037*	*0.025*	*0.053*	*0.034*
22	Y	0.969	0.997	0.995	0.985	0.990	0.999	1.015	0.993	0.038	0.017	0.019	0.024	0.033	0.025	0.043	0.028
23	Y	0.954	0.990	0.983	0.968	0.982	1.005	1.026	0.987	0.036	0.017	0.027	0.036	0.030	0.041	0.043	0.033
24	*N*	*0.965*	*1.002*	*0.999*	*0.993*	*0.986*	*1.026*	*1.039*	*1.001*	*0.033*	*0.019*	*0.026*	*0.025*	*0.038*	*0.037*	*0.050*	*0.033*
25	*N*	*0.974*	*0.995*	*1.000*	*0.991*	*0.991*	*1.021*	*1.054*	*1.004*	*0.024*	*0.015*	*0.024*	*0.027*	*0.015*	*0.034*	*0.047*	*0.027*
26	*N*	*0.978*	*1.008*	*1.004*	*0.991*	*1.004*	*0.998*	*1.023*	*1.001*	*0.034*	*0.027*	*0.022*	*0.026*	*0.023*	*0.026*	*0.060*	*0.031*

Table F.9: Machine 32 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	*1.007*	*1.056*	*1.070*	*1.051*	*1.043*	*1.031*	*0.998*	*1.037*	*0.028*	*0.013*	*0.017*	*0.013*	*0.019*	*0.038*	*0.053*	*0.026*
2	*N*	*1.022*	*1.072*	*1.081*	*1.052*	*1.049*	*1.041*	*1.007*	*1.046*	*0.031*	*0.009*	*0.013*	*0.013*	*0.025*	*0.033*	*0.061*	*0.026*
3	*N*	*0.984*	*1.052*	*1.068*	*1.038*	*1.048*	*1.028*	*0.987*	*1.029*	*0.064*	*0.014*	*0.017*	*0.014*	*0.015*	*0.037*	*0.065*	*0.032*
21	*N*	*1.018*	*1.062*	*1.073*	*1.051*	*1.051*	*1.037*	*1.006*	*1.043*	*0.034*	*0.010*	*0.010*	*0.016*	*0.022*	*0.031*	*0.056*	*0.025*
22	Y	1.030	1.068	1.076	1.051	1.061	1.042	1.011	1.048	0.023	0.012	0.011	0.011	0.014	0.022	0.050	0.020
23	Y	1.016	1.059	1.069	1.048	1.056	1.039	1.008	1.042	0.049	0.011	0.012	0.016	0.015	0.027	0.048	0.025
24	*N*	*1.011*	*1.058*	*1.072*	*1.048*	*1.050*	*1.039*	*1.005*	*1.041*	*0.054*	*0.012*	*0.015*	*0.015*	*0.020*	*0.026*	*0.055*	*0.028*
25	*N*	*1.018*	*1.064*	*1.077*	*1.049*	*1.052*	*1.046*	*1.007*	*1.045*	*0.066*	*0.014*	*0.011*	*0.012*	*0.015*	*0.028*	*0.047*	*0.028*
26	*N*	*1.023*	*1.057*	*1.075*	*1.047*	*1.047*	*1.037*	*1.012*	*1.043*	*0.018*	*0.009*	*0.011*	*0.013*	*0.020*	*0.030*	*0.042*	*0.020*

Table F.10: Machine 33 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	*1.047*	*1.054*	*1.054*	*1.045*	*1.059*	*1.028*	*0.980*	*1.038*	*0.034*	*0.023*	*0.017*	*0.031*	*0.039*	*0.059*	***0.099***	*0.043*
2	*N*	*1.037*	*1.068*	*1.077*	*1.068*	*1.090*	*1.052*	*1.026*	***1.060***	*0.057*	*0.029*	*0.022*	*0.031*	*0.038*	***0.079***	***0.099***	***0.051***
3	*N*	*1.070*	*1.073*	*1.078*	*1.062*	*1.072*	*1.041*	*1.019*	***1.059***	*0.024*	*0.018*	*0.016*	*0.028*	*0.043*	*0.069*	***0.094***	*0.042*
21	*N*	*1.022*	*1.033*	*1.033*	*1.027*	*1.034*	*1.005*	*0.978*	*1.019*	*0.027*	*0.020*	*0.017*	*0.026*	*0.031*	*0.050*	***0.080***	*0.036*
22	*N*	*1.023*	*1.020*	*1.019*	*1.011*	*1.021*	*0.997*	*0.977*	*1.010*	*0.025*	*0.017*	*0.016*	*0.028*	*0.030*	*0.052*	***0.090***	*0.037*
23	*N*	*1.018*	*1.017*	*1.018*	*1.008*	*1.012*	*0.985*	*0.969*	*1.004*	*0.018*	*0.011*	*0.014*	*0.021*	*0.028*	*0.043*	*0.070*	*0.029*
24	*N*	*0.994*	*1.018*	*1.026*	*1.020*	*1.028*	*0.998*	*0.981*	*1.009*	*0.047*	*0.020*	*0.015*	*0.026*	*0.026*	*0.052*	***0.091***	*0.039*
25	Y	1.001	1.029	1.028	1.024	1.032	1.011	0.977	1.014	0.035	0.019	0.015	0.019	0.020	0.045	0.069	0.032
26	Y	1.013	1.024	1.023	1.017	1.026	1.008	0.980	1.013	0.022	0.014	0.016	0.027	0.036	0.050	***0.085***	0.036

Table F.11: Machine 34 - All trial data during the main trial day (all laps - full dataset)

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
1	*N*	***1.102***	*1.087*	*1.071*	*1.074*	*1.093*	*1.043*	*1.048*	***1.074***	*0.032*	*0.016*	*0.025*	*0.031*	*0.032*	*0.047*	***0.084***	*0.038*
2	*N*	*1.052*	*1.052*	*1.034*	*1.043*	*1.061*	*1.024*	*1.035*	*1.043*	*0.023*	*0.015*	*0.025*	*0.026*	*0.026*	*0.044*	*0.047*	*0.029*
3	*N*	*1.070*	*1.058*	*1.042*	*1.044*	*1.071*	*1.020*	*1.030*	*1.048*	*0.040*	*0.016*	*0.018*	*0.019*	*0.024*	*0.050*	*0.060*	*0.032*
21	*N*	*1.073*	*1.061*	*1.056*	*1.054*	*1.075*	*1.039*	*1.038*	***1.057***	*0.032*	*0.016*	*0.025*	*0.023*	*0.021*	*0.033*	*0.044*	*0.028*
22	*N*	*1.076*	*1.057*	*1.056*	*1.055*	*1.074*	*1.043*	*1.039*	***1.057***	*0.021*	*0.016*	*0.028*	*0.027*	*0.028*	*0.040*	*0.042*	*0.029*
23	Y	1.042	1.033	1.026	1.031	1.048	1.011	1.017	1.030	0.025	0.013	0.018	0.023	0.027	0.041	0.065	0.030
24	Y	1.045	1.040	1.028	1.036	1.051	1.003	1.015	1.031	0.018	0.016	0.021	0.022	0.031	0.052	0.067	0.032
25	*N*	*1.050*	*1.030*	*1.028*	*1.028*	*1.039*	*1.010*	*1.003*	*1.027*	*0.031*	*0.013*	*0.026*	*0.029*	*0.020*	*0.046*	*0.056*	*0.032*
26	*N*	*1.038*	*1.039*	*1.026*	*1.027*	*1.052*	*1.015*	*0.999*	*1.028*	*0.019*	*0.016*	*0.024*	*0.026*	*0.023*	*0.033*	***0.076***	*0.031*

Table F.12: Machine 39 - All trial data during the main trial day (all laps - full dataset)

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
1	N	1.008	0.994	0.989	0.983	0.976	0.974	0.985	0.987	0.017	0.015	0.012	0.011	0.012	0.032	0.027	0.018
2	N	1.025	1.008	0.999	0.993	0.983	0.973	0.981	0.994	0.025	0.016	0.013	0.016	0.019	0.016	0.048	0.022
3	N	0.993	0.987	0.984	0.981	0.975	0.992	0.983	0.985	0.010	0.013	0.012	0.011	0.010	0.021	0.036	0.016
21	N	0.998	0.998	0.996	0.991	0.983	0.977	0.977	0.989	0.015	0.008	0.008	0.008	0.010	0.012	0.026	0.012
22	Y	1.001	0.995	0.995	0.986	0.978	0.971	0.968	0.985	0.008	0.011	0.011	0.012	0.012	0.014	0.025	0.013
23	Y	1.000	0.998	0.997	0.988	0.979	0.979	0.969	0.987	0.006	0.007	0.008	0.007	0.010	0.013	0.031	0.012
24	N	1.002	0.996	0.995	0.990	0.975	0.978	0.977	0.988	0.008	0.004	0.006	0.006	0.006	0.010	0.021	0.009
25	N	1.007	1.001	0.999	0.992	0.982	0.986	0.986	0.993	0.011	0.008	0.007	0.008	0.009	0.008	0.027	0.011
26	N	1.001	0.998	0.997	0.989	0.981	0.981	0.984	0.990	0.008	0.009	0.008	0.008	0.009	0.015	0.027	0.012

Table F.13: Machine 45 - All trial data during the main trial day (all laps - full dataset)

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
1	N	0.982	0.979	0.975	0.981	0.981	0.991	1.025	0.988	0.033	0.018	0.018	0.016	0.019	0.036	**0.074**	0.031
2	N	0.994	0.986	0.982	0.991	0.989	0.993	1.048	0.997	0.034	0.018	0.017	0.019	0.018	0.032	**0.083**	0.032
3	N	1.007	0.996	0.990	0.990	0.986	0.981	1.018	0.995	0.040	0.016	0.015	0.015	0.017	0.027	0.068	0.028
21	N	0.963	0.958	0.956	0.953	0.964	0.965	1.037	0.971	0.039	0.023	0.018	0.020	0.020	0.033	**0.074**	0.033
22	Y	0.966	0.962	0.960	0.955	0.967	0.960	1.065	0.977	0.039	0.024	0.020	0.024	0.021	0.035	0.047	0.030
23	Y	0.972	0.967	0.964	0.966	0.972	0.970	1.031	0.978	0.039	0.020	0.016	0.018	0.020	0.037	0.064	0.031
24	N	0.973	0.964	0.963	0.965	0.963	0.964	1.032	0.975	0.038	0.022	0.019	0.018	0.021	0.036	0.063	0.031
25	N	0.975	0.975	0.968	0.972	0.968	0.977	1.027	0.980	0.034	0.029	0.023	0.022	0.021	0.038	0.068	0.033
26	N	0.977	0.970	0.968	0.966	0.968	0.971	1.019	0.977	0.042	0.027	0.023	0.022	0.022	0.036	0.068	0.034

Table F.14: Machine 47 - All trial data during the main trial day (all laps - full dataset)

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
1	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	N	0.962	0.964	0.964	0.979	0.982	0.989	1.028	0.981	0.023	0.013	0.022	0.027	0.038	0.059	0.067	0.035
3	N	0.982	0.981	0.978	0.990	0.987	0.999	1.030	0.992	0.018	0.011	0.014	0.021	0.028	0.047	0.065	0.029
21	N	0.974	0.967	0.970	0.981	0.974	0.974	0.996	0.977	0.013	0.018	0.019	0.022	0.029	0.042	0.061	0.029
22	Y	0.972	0.973	0.971	0.984	0.980	0.985	1.018	0.983	0.014	0.016	0.018	0.022	0.028	0.038	0.051	0.027
23	Y	0.979	0.977	0.978	0.991	0.987	0.983	1.015	0.987	0.014	0.015	0.021	0.022	0.032	0.045	0.053	0.029
24	N	0.980	0.976	0.977	0.986	0.979	0.977	1.016	0.984	0.012	0.011	0.017	0.020	0.025	0.044	0.054	0.026
25	N	0.977	0.979	0.978	0.987	0.982	0.992	1.018	0.987	0.015	0.011	0.015	0.019	0.025	0.042	0.051	0.025
26	N	0.983	0.980	0.979	0.990	0.982	0.987	1.017	0.988	0.023	0.018	0.021	0.026	0.034	0.041	0.050	0.030

Table F.15: Machine 48 - All trial data during the main trial day (all laps - full dataset)

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
1	N	1.008	1.000	0.994	0.995	0.996	0.975	1.003	0.996	0.022	0.017	0.019	0.021	0.020	0.024	0.046	0.024
2	N	0.984	0.985	0.985	0.991	0.996	0.981	1.022	0.992	0.017	0.011	0.015	0.017	0.018	0.027	0.046	0.022
3	N	0.993	0.987	0.986	0.987	0.994	0.974	1.014	0.991	0.024	0.016	0.015	0.018	0.019	0.021	0.032	0.021
21	N	0.988	0.991	0.986	0.994	0.996	0.975	0.998	0.990	0.015	0.008	0.015	0.013	0.019	0.026	0.039	0.019
22	Y	0.994	0.986	0.983	0.988	0.994	0.976	0.997	0.988	0.015	0.014	0.015	0.013	0.019	0.019	0.033	0.018
23	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Y	0.989	0.976	0.979	0.986	0.983	0.968	0.995	0.982	0.023	0.017	0.015	0.017	0.021	0.030	0.029	0.022
25	N	0.992	0.988	0.986	0.991	0.990	0.984	1.006	0.991	0.012	0.012	0.014	0.022	0.020	0.026	0.040	0.021
26	N	0.996	0.991	0.995	0.998	0.999	0.985	1.019	0.998	0.014	0.011	0.010	0.014	0.018	0.026	0.043	0.019

Table F.16: Machine 50 - All trial data during the main trial day (all laps - full dataset)

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
1	N	0.939	0.908	0.913	0.906	**0.867**	**0.887**	**0.866**	**0.898**	0.053	0.019	0.016	0.018	0.023	0.023	0.034	0.027
2	N	0.951	0.915	0.921	0.906	**0.868**	**0.879**	**0.855**	**0.899**	0.025	0.012	0.019	0.028	0.041	0.047	0.066	0.034
3	N	0.923	**0.899**	0.909	**0.899**	**0.867**	**0.882**	**0.864**	**0.892**	0.044	0.019	0.019	0.019	0.023	0.020	0.041	0.026
21	N	1.031	1.027	1.032	1.021	1.013	1.067	1.048	1.034	0.033	0.013	0.015	0.017	0.020	0.023	0.033	0.022
22	Y	1.036	1.028	1.032	1.017	1.011	1.062	1.049	1.034	0.030	0.012	0.014	0.013	0.018	0.018	0.030	0.019
23	Y	1.032	1.027	1.035	1.021	1.011	1.064	1.043	1.033	0.041	0.013	0.014	0.015	0.017	0.020	0.033	0.022
24	N	1.028	1.026	1.034	1.021	1.006	1.058	1.043	1.031	0.032	0.011	0.012	0.010	0.017	0.017	0.028	0.018
25	N	1.031	1.025	1.033	1.019	1.008	1.068	1.050	1.033	0.026	0.009	0.012	0.012	0.016	0.017	0.026	0.017
26	N	1.032	1.026	1.033	1.019	1.015	1.066	1.048	1.034	0.038	0.012	0.013	0.012	0.016	0.022	0.031	0.020

Table F.17: Machine 51 - All trial data during the main trial day (all laps - full dataset)

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
1	N	1.000	0.956	0.977	0.963	0.969	1.014	0.979	0.980	0.025	0.037	0.022	0.019	0.020	0.022	0.030	0.025
2	N	1.010	0.980	1.000	0.982	0.982	1.024	1.000	0.997	0.036	0.030	0.018	0.018	0.019	0.020	0.024	0.024
3	N	1.034	0.985	1.008	0.990	1.000	1.040	1.009	1.010	0.022	0.032	0.017	0.016	0.017	0.022	0.017	0.020
21	N	1.027	1.003	1.020	1.015	1.009	1.031	1.069	1.025	0.030	0.020	0.015	0.013	0.015	0.021	0.030	0.021
22	Y	1.022	1.002	1.014	1.007	1.002	1.030	1.052	1.018	0.021	0.023	0.016	0.014	0.016	0.011	0.025	0.018
23	Y	1.032	1.006	1.026	1.015	1.008	1.034	1.059	1.026	0.027	0.025	0.018	0.009	0.012	0.014	0.034	0.020
24	N	1.040	1.012	1.032	1.025	1.021	1.040	1.071	1.034	0.032	0.024	0.017	0.014	0.014	0.018	0.026	0.021
25	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F.18: Machine 52 - All trial data during the main trial day (all laps - full dataset)

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
1	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	N	0.970	0.970	0.966	0.975	0.985	0.988	0.993	0.978	0.027	0.010	0.012	0.016	0.016	0.021	0.042	0.021
3	N	0.991	0.986	0.981	0.987	0.993	0.985	0.999	0.989	0.012	0.008	0.009	0.012	0.013	0.027	0.026	0.015
21	N	0.984	0.978	0.979	0.986	0.987	0.980	0.969	0.980	0.019	0.013	0.012	0.014	0.014	0.017	0.022	0.016
22	Y	0.989	0.982	0.981	0.982	0.988	0.986	0.995	0.986	0.013	0.011	0.011	0.015	0.016	0.021	0.049	0.020
23	Y	0.987	0.979	0.979	0.988	0.985	0.987	0.965	0.982	0.011	0.012	0.011	0.014	0.019	0.015	0.029	0.016
24	N	0.981	0.978	0.979	0.986	0.981	0.977	0.972	0.979	0.011	0.009	0.009	0.010	0.007	0.015	0.033	0.013
25	N	0.996	0.992	0.988	0.997	0.999	1.001	0.986	0.994	0.013	0.012	0.011	0.012	0.014	0.014	0.033	0.016
26	N	0.987	0.988	0.987	0.997	0.996	0.999	0.986	0.991	0.018	0.012	0.011	0.013	0.014	0.014	0.023	0.015

Table F.19: Machine 53 - All trial data during the main trial day (all laps - full dataset)

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
1	N	1.004	1.000	0.995	1.007	1.005	1.016	1.000	1.004	0.026	0.012	0.012	0.018	0.017	0.024	0.015	0.018
2	N	1.005	1.007	1.003	1.012	1.012	1.025	1.011	1.011	0.029	0.017	0.016	0.016	0.014	0.026	0.018	0.019
3	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	N	1.014	1.018	1.016	1.019	1.014	1.014	0.993	1.013	0.017	0.014	0.015	0.016	0.018	0.018	0.023	0.017
22	Y	1.018	1.019	1.017	1.017	1.017	1.011	1.008	1.015	0.019	0.009	0.009	0.007	0.013	0.012	0.014	0.012
23	Y	1.023	1.022	1.027	1.028	1.023	1.025	1.014	1.023	0.010	0.008	0.012	0.011	0.013	0.014	0.025	0.013
24	N	1.029	1.022	1.027	1.028	1.018	1.024	1.012	1.023	0.021	0.011	0.013	0.011	0.013	0.015	0.029	0.016
25	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

F.2 Final reproducibility trial data for selected laps

Table F.20: Final trial data for reproducibility (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	22	1.018	0.992	0.987	0.988	0.998	1.000	0.994	0.997	0.021	0.010	0.011	0.011	0.009	0.009	0.028	0.014	
	23	1.013	0.993	0.985	0.988	0.990	1.010	1.010	0.999	0.013	0.007	0.016	0.018	0.009	0.013	0.053	0.019	
5	22	1.016	1.026	1.019	1.016	1.012	0.979	0.989	1.008	0.023	0.026	0.028	0.035	0.043	0.064	0.069	0.041	Station 5 D7
	23	1.030	1.026	1.017	1.017	1.005	0.978	0.978	1.010	0.029	0.033	0.035	0.046	0.048	0.069	0.069	0.047	Station 5 D7
10	22	1.013	0.996	0.999	1.000	0.997	0.992	0.995	0.999	0.023	0.011	0.010	0.009	0.008	0.010	0.011	0.012	
	23	1.035	0.994	0.996	0.998	0.992	0.987	0.985	0.998	0.035	0.009	0.009	0.008	0.010	0.010	0.011	0.013	
11	22	0.971	0.980	0.979	0.990	0.981	0.977	0.986	0.980	0.021	0.018	0.029	0.013	0.025	0.028	0.025	0.023	
	23	0.964	0.964	0.969	0.986	0.976	0.982	0.980	0.974	0.018	0.027	0.017	0.026	0.019	0.024	0.033	0.023	
13	22	1.055	1.049	1.057	1.046	1.033	1.031	1.036	1.044	0.017	0.020	0.030	0.026	0.030	0.060	0.058	0.035	
	23	1.053	1.051	1.048	1.049	1.039	1.035	1.052	1.047	0.019	0.023	0.029	0.028	0.036	0.033	0.041	0.030	
15	22	0.971	0.976	0.977	0.975	0.986	0.993	0.981	0.980	0.013	0.010	0.011	0.026	0.033	0.024	0.036	0.022	
	23	0.974	0.975	0.977	0.982	0.983	0.986	0.985	0.980	0.015	0.014	0.018	0.021	0.021	0.030	0.043	0.023	
16	22	0.959	0.984	0.986	0.992	1.001	0.994	0.979	0.985	0.036	0.021	0.019	0.019	0.022	0.026	0.040	0.026	
	23	0.956	0.989	0.988	0.994	0.994	0.997	0.982	0.986	0.029	0.013	0.009	0.012	0.012	0.028	0.024	0.018	
28	22	0.969	0.997	0.995	0.985	0.990	0.999	1.015	0.993	0.038	0.017	0.019	0.024	0.033	0.025	0.043	0.028	
	23	0.954	0.990	0.983	0.968	0.982	1.005	1.026	0.987	0.036	0.017	0.027	0.036	0.030	0.041	0.043	0.033	
32	22	1.030	1.068	1.076	1.051	1.061	1.042	1.011	1.048	0.023	0.012	0.011	0.011	0.014	0.022	0.050	0.020	
	23	1.016	1.059	1.069	1.048	1.056	1.039	1.008	1.042	0.049	0.011	0.012	0.016	0.015	0.027	0.048	0.025	
33	25	1.001	1.029	1.028	1.024	1.032	1.011	0.977	1.014	0.035	0.019	0.015	0.019	0.020	0.045	0.069	0.032	
	26	1.013	1.024	1.023	1.017	1.026	1.008	0.993	1.015	0.022	0.014	0.016	0.027	0.036	0.050	0.070	0.033	Station 5 D7
34	23	1.042	1.033	1.026	1.031	1.048	1.011	1.017	1.030	0.025	0.013	0.018	0.023	0.027	0.041	0.065	0.030	
	24	1.045	1.040	1.028	1.036	1.051	1.003	1.015	1.031	0.018	0.016	0.021	0.022	0.031	0.052	0.067	0.032	
39	22	1.001	0.995	0.995	0.986	0.978	0.971	0.968	0.985	0.008	0.011	0.011	0.012	0.012	0.014	0.025	0.013	
	23	1.000	0.998	0.997	0.988	0.979	0.979	0.969	0.987	0.006	0.007	0.008	0.007	0.010	0.013	0.031	0.012	

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	
45	22	0.966	0.962	0.960	0.955	0.967	0.960	1.065	0.977	0.039	0.024	0.020	0.024	0.021	0.035	0.047	0.030	
	23	0.972	0.967	0.964	0.966	0.972	0.970	1.031	0.978	0.039	0.020	0.016	0.018	0.020	0.037	0.064	0.031	
47	22	0.972	0.973	0.971	0.984	0.980	0.985	1.018	0.983	0.014	0.016	0.018	0.022	0.028	0.038	0.051	0.027	
	23	0.979	0.977	0.978	0.991	0.987	0.983	1.015	0.987	0.014	0.015	0.021	0.022	0.032	0.045	0.053	0.029	
48	22	0.994	0.986	0.983	0.988	0.994	0.976	0.997	0.988	0.015	0.014	0.015	0.013	0.019	0.019	0.033	0.018	
	24	0.989	0.976	0.979	0.986	0.983	0.968	0.995	0.982	0.023	0.017	0.015	0.017	0.021	0.030	0.029	0.022	
50	22	1.036	1.028	1.032	1.017	1.011	1.062	1.049	1.034	0.030	0.012	0.014	0.013	0.018	0.018	0.030	0.019	
	23	1.032	1.027	1.035	1.021	1.011	1.064	1.043	1.033	0.041	0.013	0.014	0.015	0.017	0.020	0.033	0.022	
51	22	1.022	1.002	1.014	1.007	1.002	1.030	1.052	1.018	0.021	0.023	0.016	0.014	0.016	0.011	0.025	0.018	
	23	1.032	1.006	1.026	1.015	1.008	1.034	1.059	1.026	0.027	0.025	0.018	0.009	0.012	0.014	0.034	0.020	
52	22	0.989	0.982	0.981	0.982	0.988	0.986	0.995	0.986	0.013	0.011	0.011	0.015	0.016	0.021	0.049	0.020	
	23	0.987	0.979	0.979	0.988	0.985	0.987	0.965	0.982	0.011	0.012	0.011	0.014	0.019	0.015	0.029	0.016	
53	22	1.018	1.019	1.017	1.017	1.017	1.011	1.008	1.015	0.019	0.009	0.009	0.007	0.013	0.012	0.014	0.012	
	23	1.023	1.022	1.027	1.028	1.023	1.025	1.014	1.023	0.010	0.008	0.012	0.011	0.013	0.014	0.025	0.013	

Appendix G Accreditation trial – Trial results

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

Highways England 2020 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 2020 trial run by TRL held on the Horiba-MIRA proving ground between the 22nd and 24th of September 2020.

Other titles from this subject area

PPR976	Highways England 2019 National Dynamic Plate Test device Accreditation Trial. S Brittain. 2022
PPR1017	Highways England 2018 National Dynamic Plate Test device Accreditation Trial. S Brittain. 2022
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PPR945	Highways England 2016 National Dynamic Plate Test device Accreditation Trial. S Brittain, 2020

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ISSN 2514-9652

ISBN 978-1-913246-96-9

PPR974