THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR947

Highways Agency 2014 National Dynamic Plate Test device Accreditation Trial

S Brittain

Report details

Report prepared for:	Highways Agency, Network Services		
Project/customer reference:	422(4/45/12)HALC: PAAQA		
Copyright:	© TRL Limited		
Report date:	14/01/2020		
Report status/version:	1.1		
Quality approval:			
Stuart Brittain (Project Manager)	S Brittain	Brian Ferne (Technical Reviewer)	B Ferne

Disclaimer

Contents amendment record

This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Reviewer
0.1	28/01/2015	Draft for review by Project Sponsor	S Brittain	B Ferne
1.0	05/09/2016	Issued version	S Brittain	B Ferne
1.1	14/01/2020	Converted to published report for historic continuity	S Brittain	B Ferne & P Langdale

Document last saved on:	14/01/2020 15:59
Document last saved by:	Stuart Brittain

Executive Summary

The 2014 UK Dynamic Plate Test device (DPT) accreditation trial was held on the Twin Straights on the MIRA proving ground, on the 11th and 12th November 2014. This was the sixteenth 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 Agency (HA) strategic road network (SRN). DPT devices include Falling Weight Deflectometers (FWD), Heavy Weight Deflectometers (HWDs) and Super Heavy Weight Deflectometers (SHWDs).

The performance of individual machines was assessed by examining and monitoring 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 HA strategic road network.

A total of twenty-one machines took part in the trial, consisting of eleven trailer-mounted Dynatest FWDs, eight Dynatest trailer-mounted HWDs, one Grontmij trailer-mounted FWDs and one Grontmij trailer-mounted HWD.

The trials followed a similar format to that which was used successfully on the TRL small road system from 2004 through to April 2010 and in November 2012, and at the MIRA test track in November 2010 and October 2011 onwards. The Trial is split into 3 days with machine inspections, distance calibration, and initial testing held on the first day. The main testing is then held on the second day, and the third day is used for contingency in case of bad weather or other unforeseen circumstances. The tests undertaken this time comprised the following:

- Reproducibility of deflection measurement (a mandatory test)
- Accuracy of measurement of elapsed distance against an independent reference (a mandatory test)
- Repeatability of deflection measurement (a non-mandatory test)
- Accuracy of measurement of pavement temperature against an independent reference (a non-mandatory test)
- Accuracy of 3-dimensional positional data where fitted (a non-mandatory test)

These tests and associated acceptance criteria are based on but not identically to those published by the CROW standards organisation in the Netherlands. In August 2011 they issued an updated version of their recommendations (CROW 2011). The first test and criteria are the same as used in previous trials and must be met successfully for a machine to receive accreditation. Passing the second test is also mandatory for accreditation to provide deflection data. Based on the results from this trial and previous trials, it is recommended that the repeatability criteria are transformed into a mandatory criterion for future trials.

All twenty-one machines met the mandatory reproducibility trial requirements for Field Calibration Factor (FCF) and elapsed distance. One machine failed the mandatory criteria for Standard Deviation of Deviation Ratio (SDDR). Following a repair, this machine was re-tested in December 2014 and subsequently found to be acceptable.

Eighteen of the twenty-one machines achieved a high performance rating in all three parts of the non-mandatory repeatability assessment (mean of applied load, standard deviation of applied load and standard deviation of normalised deflections). Two machines achieved a medium performance in the standard deviation of normalised deflections criteria, and another achieved a medium performance in the mean load applied criteria (all of these machines achieved high performance in the other repeatability criteria).

Fifteen of the twenty-one machines achieved a high performance in the non-mandatory temperature measurement assessment. One machine achieved a medium, three machines achieved a low, and the remaining two machines were given very low performance rating.

3-dimensional position data was supplied by six of the test machines. Three of these machines achieved a high performance level, one achieved a low performance level. The remaining two machines supplied invalid data.

In summary, all of the twenty-one machines that participated in the November 2014 DPT accreditation trial met the mandatory requirements of the HA's annual accreditation trial.

The results from the trial are discussed in this report and are provided in the accreditation certificates issued to the trial participants. These certificates are also accessible at:

http://www.ukroadsliaisongroup.org/en/asset-condition/road-condition-information/data-collection/dynamic-plate-test-devices-dpt/index.cfm

Table of Contents

1 Introduction

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

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

The objectives of the 2014 DPT Accreditation trial were:

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

The sixteenth mandatory UK DPT accreditation trial was held on 11th and 12th November 2014 on behalf of the Highways Agency (HA). The trial followed the basic format that was used successfully in the previous mandatory trials carried out since 1999. The 2014 trial included the following mandatory checks:

- Reproducibility
- Distance measurement

And the following non-mandatory checks

- Repeatability
- Temperature measurement
- OSGR data

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

From 1999 to April 2010 the trials were conducted on the Small Roads System at TRL. The trial was then conducted at the Motor Industry Research Association (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 and 2014 trials were held on the proving grounds at MIRA. This report describes the conduct and findings of the November 2014 accreditation trial and presents the details of the machines that took part in the trial.

2 Trial Format

2.1 Participants

Twenty-one machines (all trailer-mounted) took part in the 2014 HA DPT accreditation trial, comprising twelve FWDs and nine HWDs. A total of twelve owning organisations took part, with the machines brought by each as follows:

ALC (MoD)	4 x Dynatest 8082 HWD
CET Infrastructure	Dynatest 8002 FWD
Dynatest	Dynatest 8012 FWD
Forth Bridge Constructors JV	Dynatest 8002 FWD
Milestone Pavement Technologies	Grontmij Primax 1500 FWD
PMS Ltd. (Eire)	2 × Dynatest 8002 FWD and 1 x Dynatest 8082 HWD
PTS	1 × Dynatest 8002 FWD and 1 x Dynatest 8082 HWD
Pulse Surveying Ltd.	Dynatest 8002 FWD
Stanger Testing Services	Dynatest 8002 FWD
TestConsult Ltd.	Grontmij Primax 2500 HWD
TRL	Dynatest 8002 FWD
URS	2×Dynatest 8002 FWD, 2×Dynatest 8082 HWD

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

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

2.2 Preparation of vehicles

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

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

For the repeatability testing the following were also specified:

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

For the reproducibility testing the following were also specified:

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

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

2.3 Inspection of vehicles

Operators were requested to provide details of the latest manufacturer's calibration and their own dynamic calibrations prior to the start of the trial. The machines were subsequently checked by a TRL inspector before testing began to ensure that the machines were set up correctly and configured as required by the trial. The findings are provided 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 MIRA proving ground. Each section contained three test stations (12 stations in total) which were clearly marked out using road paint (see Figure 2.1 below) and swept clear of debris prior to the trial. An additional station (number 13) is located on a concrete section and this station (along with 2, 5 and 8) is used in the repeatability testing. Two additional test lengths were set up; one to allow operators to undertake distance calibrations and one for the odometer test. Nominal construction details for the 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

The pavement temperature was measured throughout the trial using two pairs of temperature sensors connected to two data loggers located near stations 1 and 9. These devices were set to record temperature every minute at depths of 40mm and 100mm within the pavement.

2.6 Test Programme

Appendix D contains the detailed instructions provided to participants regarding the conduct of the trial. An outline of the programme is provided below.

2.6.1 Day 1 – Inspection and Repeatability

Day 1 is used to conduct machine inspections, repeatability tests and a check lap. The check lap is designed to give new operators the chance to familiarise themselves with the course, and to seek to highlight any obvious problems with machines that would otherwise delay progress during the main part of the trials on the following day.

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

The check lap follows the same format as used for the main day (day 2) with five replicate drops at each of the standard twelve test stations. The peak values of load and deflection are recorded as well as time histories. For this testing it is recommended that the load "Seek" setting is switched on (if available).

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

During this day the crews are also asked to perform a distance calibration using a marked out length (400m).

2.6.2 Day 2 – Main running trial day

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

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

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

During each lap the crews are asked to make temperature measurements using a pre-drilled hole near one of the temperature loggers. In addition, on returning to the start of the test site the operators are asked to measure a predefined length to provide an assessment of the odometers fitted to the equipment.

2.6.3 Day 3 – Contingency day

Day 3 is reserved for contingency for bad weather or other unforeseen circumstances.

3 Trial Criteria

3.1 Repeatability tests

Repeatability tests were introduced in the 2011 trial at MIRA and have been included in the trials since. While remaining a non-mandatory test, there is an aim to use them as pass/fail criteria in future accreditation trials. The repeatability tests involve a set of twelve drops on four test stations. During this testing the load targeting or "seeking" is switched off. There are 3 criteria applied to the repeatability tests, these criteria are:

1. The mean load applied shall be within 10% of the 50kN target load (707 kPa)
2. The standard deviation of the load recorded shall be less than, or equal to two per cent of the mean of the recorded values.
3. The standard deviation of the normalised deflections shall be 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.

These three criteria are given a performance rating from High to Very Low as follows:

- HIGH: Meets the criteria for all of the tests
- MEDIUM: Fails to meet the criteria once
- LOW: Fails to meet the criteria twice
- VERY LOW: Fails to meet the criteria more than twice

3.2 Reproducibility tests

As in previous accreditation trials, the reproducibility results have been analysed following the CROW procedure (CROW, 2011). This procedure uses a series of statistical tests to eliminate outlying data in order to define a reference deflection basin for each test station. For each deflection sensor, the ratio of the measured mean deflection to the reference deflection, averaged over all test stations, is defined as the Field Calibration Factor (FCF). The overall FCF for each machine is calculated by averaging the FCF values for the individual sensors. The FCF therefore indicates, on average, how well the deflections recorded by each machine relate to the reference deflection basins.

The difference between the measured deflection at each station and the reference deflection basin, expressed as a fraction of the reference deflection, is known as the Deviation Ratio. For each machine, the Standard Deviation of the Deviation Ratio (SDDR) is calculated over all test stations and gives an indication of the consistency with which it tends to over- or under-read during the lap. Following the preliminary trials in 1998 and 1999 it was proposed that FCF and SDDR should be used as the basis for defining acceptance criteria at future trials, with proposed tolerances as shown in Table 3.1. These criteria have since been adopted and used as the pass criteria for the mandatory trials.

Occasionally, a machine will produce isolated anomalous geophone readings which result in FCF or SDDR values outside of acceptable limits. To account for this, the accreditation trial procedure allows for the measurement from a single geophone from one test station to be removed from the analysis of each lap.

Table 3.1 Reproducibility Pass 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

3.3 Location referencing

3.3.1 Distance measurement

In order to assess the location referencing, the operators were asked to provide distance measurements of a defined length (around 600m) on three test laps. This data is then assessed against the criteria given in Table 3.2. Although most of the machines only report distances to the nearest metre the defined length was measured to the nearest 0.1m.

Table 3.2 Distance measurement criteria

	Test criteria
Pass	All 3 of the laps were within 2m or 1% of the length (whichever is greater)
Fail	Otherwise or if data is missing

3.3.2 OSGR co-ordinates

For fitting of data from other survey machines (e.g. skid resistance and TRACS) HA require that the data is supplied with OSGR co-ordinates. This is currently not a requirement for DPT type devices. Due to this, 3-dimensional position devices are not currently fitted to all of the DPT machines in the fleet. In addition the machines thus fitted supply positional data in lat/long format and therefore it is necessary to convert the supplied data into OSGR format before comparing it to the reference. The data supplied allows for a conversion of the horizontal position, however there is insufficient data to provide the conversion of the altitude data. Therefore only the horizontal position will be assessed. Using the criteria for the other survey machines as a guide, the criteria used to assess the horizontal position of data are given in Table 3.3.

Table 3.3 OSGR measurement criteria

	Test criteria
High	75% of data is within 2m of the reference
Medium	75% of the data is within 5m of the reference
Low	Otherwise

3.4 Operator temperature measurements

The DPT operators are asked to use their own equipment to record temperatures from two pre-drilled 100mm depth holes. These holes were at two separate points of the track and

adjacent to the temperature loggers. The DPT operators are asked to provide four sets of measurements, one set per lap, over the course of the day and are assessed against the criteria given in Table 3.4.

Table 3.4 Temperature measurement criteria

	Test criteria
High	At least 7 of the 8 measurements were within 1°C of the reference
Medium	At least 5 of the 8 measurements were within 1°C of the reference
Low	At least 2 of the 8 measurements were within 1°C of the reference
Very Low	Otherwise

4 Results - Day 1

4.1 Machine set-up and configuration

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

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

Table 4.1 Summary of DPT configurations on arrival

Checklist item	Number compliant (out of 21)
Completed Check list returned to TRL before trial	17
Provide evidence and date of last manufacturer's calibration	20
Provide evidence and date of last dynamic calibration.	7
Provide evidence and date of last tower calibration	11
Calibration details correct in field program	18
All seven geophones in correct positions	20
Correct seating of frame	21

Following the 2006 accreditation Trial, it had been agreed with the DPT operators that routine dynamic and tower calibration records should be made available for viewing at the 2007 and subsequent accreditation trials.

The dates supplied by the contractors for their latest calibrations (regardless of whether evidence of the calibration was supplied) is shown in Appendix A.

4.2 Repeatability tests

Repeatability tests are conducted using stations 2, 5, 8 and 13 and the test criteria can be found in section 3.1. Two machines (8 and 34) provided data on the cusp of the criteria threshold on day 1 and were asked to inspect their machines (prior to the reproducibility tests on day 2) and repeated the repeatability assessment on day 2. In the tables below, the data for machines 8 and 34 are from day 2 and the data for the other machines from day 1.

The means and standard deviations of the loads applied in these repeatability tests are summarised in Table 4.2. A result is highlighted in bold and red font if it does not meet the associated criteria.

Table 4.2 Statistics on loads applied in repeatability tests

Machine number	Applied loads							
	Station 2		Station 5		Station 8		Station 13	
	Mean (KPa).	CoV (%)	Mean (KPa).	CoV (%)	Mean (KPa).	CoV (%)	Mean (KPa).	CoV (%)
5	714.7	0.2%	713.5	0.5%	703.2	0.2%	747.7	0.5%
6	661.4	0.2%	659.3	0.2%	656.2	0.2%	659.4	0.1%
8	749.9	0.4%	729.6	0.3%	735.5	0.2%	749.9	0.4%
9	770.4	0.5%	754.7	0.4%	759.3	0.5%	775.5	0.5%
10	723.3	0.4%	707.7	0.3%	714.0	0.2%	718.7	0.4%
11	705.8	0.3%	690.9	0.2%	697.0	0.2%	695.6	0.3%
13	745.9	0.7%	739.3	0.3%	726.9	0.6%	747.8	0.4%
15	691.4	0.2%	672.6	0.1%	676.4	0.2%	676.8	0.3%
16	728.0	0.2%	707.2	0.4%	712.5	0.5%	714.4	0.3%
28	769.4	0.2%	755.8	0.2%	760.6	0.1%	761.0	0.2%
30	654.6	0.2%	641.3	0.3%	642.3	0.2%	643.5	0.2%
32	689.0	0.2%	685.7	0.6%	685.6	0.5%	679.9	0.6%
33	713.3	0.3%	710.7	0.2%	712.9	0.2%	709.2	0.1%
34	735.8	0.5%	731.2	0.4%	720.1	0.4%	729.3	0.4%
36	708.6	1.0%	710.2	0.6%	707.8	1.2%	705.7	0.8%
37	649.8	0.2%	**632.7**	0.3%	641.3	0.2%	648.0	0.3%
38	714.1	1.2%	712.5	0.9%	715.9	0.9%	704.4	1.0%
39	699.1	0.3%	671.7	0.3%	688.1	0.2%	688.6	0.4%
40	715.7	0.1%	710.1	0.1%	710.7	0.1%	709.9	0.2%
41	691.5	0.4%	685.5	0.1%	683.6	0.3%	684.5	0.2%
42	673.1	0.1%	667.7	0.1%	663.6	0.1%	665.5	0.2%

Mean = Mean of applied loads (acceptable range = 636 to 778)

CoV = standard deviation of applied loads expressed as a percentage of the mean (acceptable value ≤2%) i.e. coefficient of variation

It can be seen from this table that one machine (37) achieves a medium performance for the mean of the applied load (i.e. the load applied is within 10% of the target load) and the remaining machines achieve a high performance. In addition all of the machines achieve a high performance for the standard deviation of the applied load (the coefficient of variation of the applied load is less than or equal to 2%).

The summary data for the assessment of the third criterion is given in Table 4.3. As this criterion is based on a variable limit the numbers are presented as the ratio of the standard deviation to the normalised deflections to the test criterion. This ratio should therefore not exceed unity (i.e. 1). Stations where this ratio is less than 0.25 are shaded blue, less than 0.5 green, less than 0.75 yellow, less than 1 orange and where the criteria is exceeded (>=1) are shaded red. The detailed mean and standard deviation values from each repeatability test can be found in Appendix E.

Table 4.3 Repeatability summary for deviation of deflections

Machine number	Station	Ratio of standard deviation of normalised deflections to the test criteria						
		D1	D2	D3	D4	D5	D6	D7
5	2	0.19	0.08	0.13	0.11	0.07	0.09	0.09
	5	0.43	0.35	0.31	0.24	0.18	0.13	0.14
	8	0.20	0.16	0.14	0.12	0.11	0.06	0.07
	13	0.27	0.24	0.17	0.21	0.15	0.23	0.36
6	2	0.19	0.17	0.15	0.12	0.11	0.26	0.12
	5	0.27	0.22	0.21	0.48	0.46	0.15	0.97
	8	0.14	0.11	0.15	0.06	0.26	0.30	0.25
	13	0.19	0.16	0.24	0.22	0.39	0.71	0.37
8	2	0.18	0.22	0.92	0.42	0.49	0.18	0.09
	5	0.31	0.73	0.23	0.40	0.13	0.26	0.06
	8	0.28	0.25	0.26	0.40	0.15	0.08	0.05
	13	0.18	0.22	0.92	0.42	0.49	0.18	0.09
9	2	0.16	0.22	0.26	0.17	0.17	0.12	0.25
	5	0.28	0.30	0.24	0.10	0.15	0.11	0.18
	8	0.21	0.21	0.14	0.15	0.46	0.41	0.40
	13	0.13	0.25	0.12	0.28	0.15	0.27	0.39
10	2	0.07	0.09	0.05	0.07	0.08	0.06	0.07
	5	0.29	0.21	0.14	0.14	0.20	0.12	0.11
	8	0.20	0.13	0.16	0.10	0.05	0.04	0.07
	13	0.15	0.10	0.10	0.15	0.23	0.07	0.10
11	2	0.12	0.16	0.15	0.06	0.24	0.04	0.17
	5	0.15	0.21	0.18	0.22	0.20	0.06	0.03
	8	0.17	0.11	0.13	0.16	0.25	0.08	0.15
	13	0.21	0.09	0.12	0.16	0.08	0.20	0.33
13	2	0.28	0.27	0.15	0.14	0.15	0.08	0.10
	5	0.31	0.20	0.18	0.17	0.09	0.12	0.15
	8	0.33	0.34	0.28	0.21	0.17	0.15	0.15
	13	0.79	0.17	0.19	0.15	0.10	0.09	0.06
15	2	0.06	0.02	0.03	0.15	0.07	0.05	0.06
	5	0.19	0.19	0.13	0.11	0.10	0.07	0.09
	8	0.11	0.11	0.05	0.05	0.06	0.07	0.06
	13	0.29	0.05	0.10	0.07	0.06	0.14	0.04
16	2	0.14	0.19	0.25	0.05	0.23	0.21	0.25
	5	0.16	0.21	0.26	0.20	0.22	0.18	0.06
	8	0.16	0.21	0.18	0.14	0.15	0.14	0.13
	13	0.18	0.16	0.20	0.20	0.17	0.19	0.22
28	2	0.25	0.07	0.11	0.07	0.06	0.06	0.20
	5	0.18	0.13	0.10	0.10	0.15	0.10	0.05
	8	0.11	0.13	0.13	0.05	0.11	0.07	0.18
	13	0.09	0.09	0.15	0.20	0.09	0.14	0.06
30	2	1.36	0.11	0.14	0.04	0.15	0.06	0.13
	5	0.25	0.37	0.12	0.46	0.07	0.11	0.23
	8	0.15	0.08	0.07	0.09	0.09	0.05	0.12
	13	0.22	0.10	0.09	0.23	0.10	0.17	0.27
32	2	0.37	0.22	0.23	0.22	0.25	0.16	0.02
	5	0.28	0.28	0.11	0.34	0.27	0.38	0.26
	8	0.21	0.28	0.20	0.38	0.27	0.19	0.43
	13	0.38	0.23	0.23	0.24	0.19	0.25	0.23

Machine number	Station	Ratio of standard deviation of normalised deflections to the test criteria						
		D1	D2	D3	D4	D5	D6	D7
33	2	0.26	0.09	0.23	0.07	0.26	0.28	0.34
	5	0.19	0.19	0.28	0.11	0.07	0.22	0.24
	8	0.07	0.15	0.11	0.28	0.07	0.23	0.16
	13	0.31	0.23	0.13	0.05	0.21	0.22	0.62
34	2	0.43	0.14	0.25	0.11	0.21	0.34	0.06
	5	0.58	0.47	0.37	0.36	0.26	0.29	0.21
	8	0.34	0.41	0.48	0.29	0.34	0.21	0.32
	13	1.33	0.31	0.18	0.15	0.16	0.16	0.55
36	2	0.53	0.09	0.10	0.19	0.12	0.11	0.11
	5	0.29	0.18	0.15	0.10	0.08	0.05	0.07
	8	0.39	0.14	0.13	0.14	0.10	0.10	0.05
	13	0.25	0.07	0.07	0.07	0.07	0.06	0.05
37	2	0.06	0.18	0.16	0.04	0.03	0.29	0.02
	5	0.18	0.13	0.14	0.17	0.24	0.22	0.60
	8	0.17	0.11	0.30	0.11	0.23	0.06	0.16
	13	0.18	0.22	0.11	0.10	0.19	0.14	0.17
38	2	0.16	0.14	0.15	0.12	0.12	0.09	0.09
	5	0.21	0.22	0.21	0.26	0.22	0.15	0.13
	8	0.16	0.14	0.18	0.18	0.19	0.13	0.13
	13	0.16	0.16	0.14	0.14	0.16	0.11	0.10
39	2	0.26	0.15	0.07	0.06	0.21	0.13	0.14
	5	0.30	0.15	0.20	0.16	0.27	0.22	0.04
	8	0.28	0.22	0.24	0.30	0.25	0.27	0.28
	13	0.22	0.17	0.15	0.23	0.18	0.09	0.24
40	2	0.08	0.05	0.05	0.04	0.06	0.02	0.07
	5	0.23	0.14	0.13	0.25	0.11	0.16	0.18
	8	0.08	0.11	0.08	0.06	0.06	0.05	0.10
	13	0.06	0.15	0.15	0.50	0.08	0.14	0.04
41	2	0.13	0.14	0.18	0.14	0.22	0.30	0.62
	5	0.26	0.21	0.19	0.23	0.18	0.27	0.34
	8	0.18	0.20	0.20	0.39	0.21	0.23	0.26
	13	0.28	0.31	0.22	0.25	0.28	0.31	0.04
42	2	0.24	0.24	0.17	0.14	0.17	0.21	0.16
	5	0.35	0.20	0.19	0.21	0.03	0.16	0.26
	8	0.22	0.10	0.11	0.29	0.14	0.30	0.02
	13	0.24	0.17	0.25	0.09	0.08	0.06	0.22

On examination of the data it can be seen that two of the machines (30 and 34) achieve a medium performance for standard deviation of normalised deflections. The remaining machines achieve a high performance. In addition 78% of the ratios are within 0.25.

4.3 Day 1 check lap

A check lap is conducted on Day 1 to provide early data to highlight any obvious problems with the survey machines to allow corrective action to be undertaken prior to the mandatory reproducibility testing on day 2.

The data for the check lap was assessed in the same manner as for the reproducibility tests as detailed in section 3.2.2 and is shown graphically in Figure 4.1 and Figure 4.2.

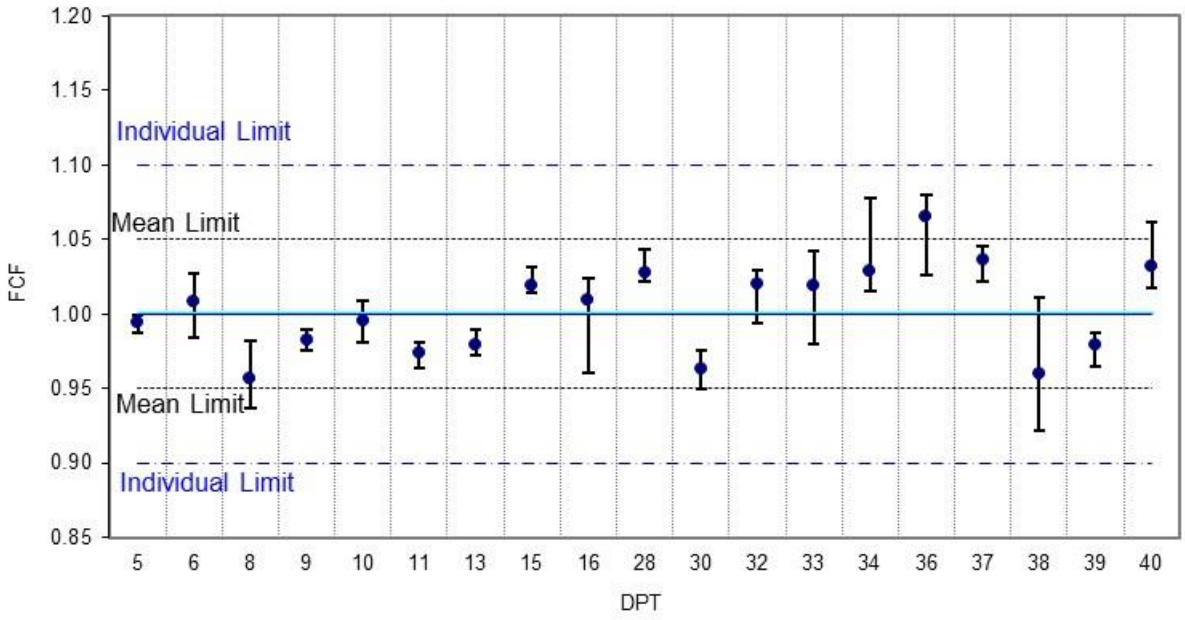

Figure 4.1 Field calibration factors (FCF) (check lap, no geophones removed)

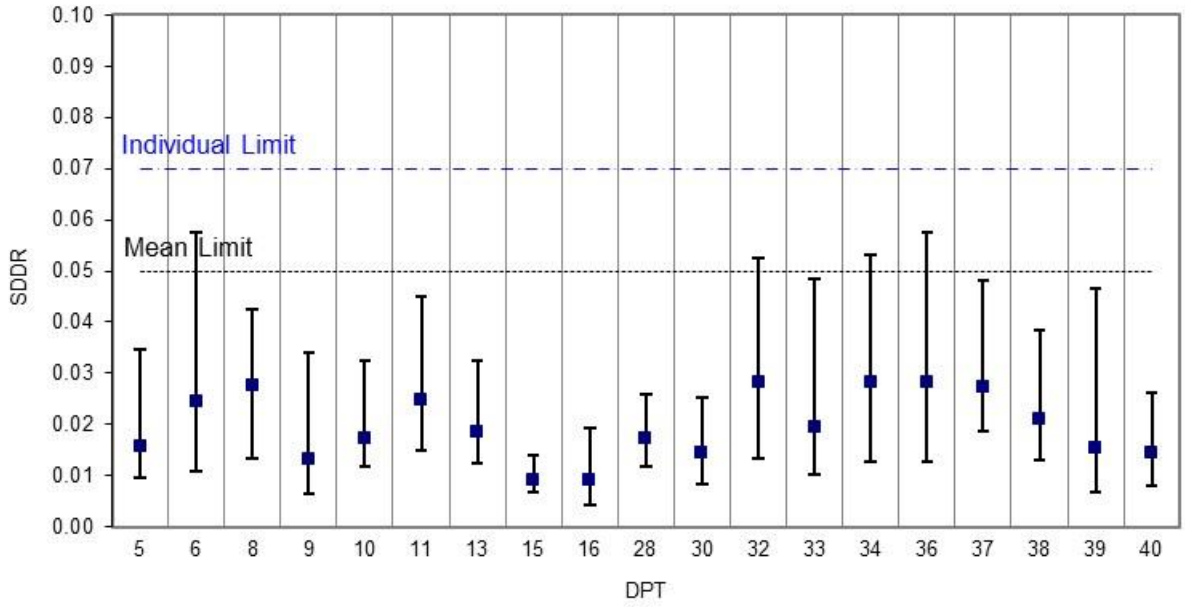

Figure 4.2 Standard deviation of the deviation ratio (SDDR) (check lap, no geophones removed)

On initial examination of the check lap data it was identified that Machine 36 was outside of the criteria for the mean FCF, and the removal of a single geophone reading would not bring it within the test criteria. The operators of this machine were notified of this issue so that they could investigate their machine before the main testing on day two.

5 Results - Day 2

5.1 Temperature variation

A maximum “asphalt layer” (at 100mm depth) temperature change of 3°C during each test lap is recommended under the CROW procedure (CROW 2011) on which the UK trials are based. The aim of the limit is to ensure that, as far as practicable, all machines are subject to the same pavement conditions during any single test lap.

On day 2, pavement temperatures were recorded at 40 and 100mm depths near stations 1 and 9. The temperatures remained relatively stable over the day as shown in Figure 5.1.

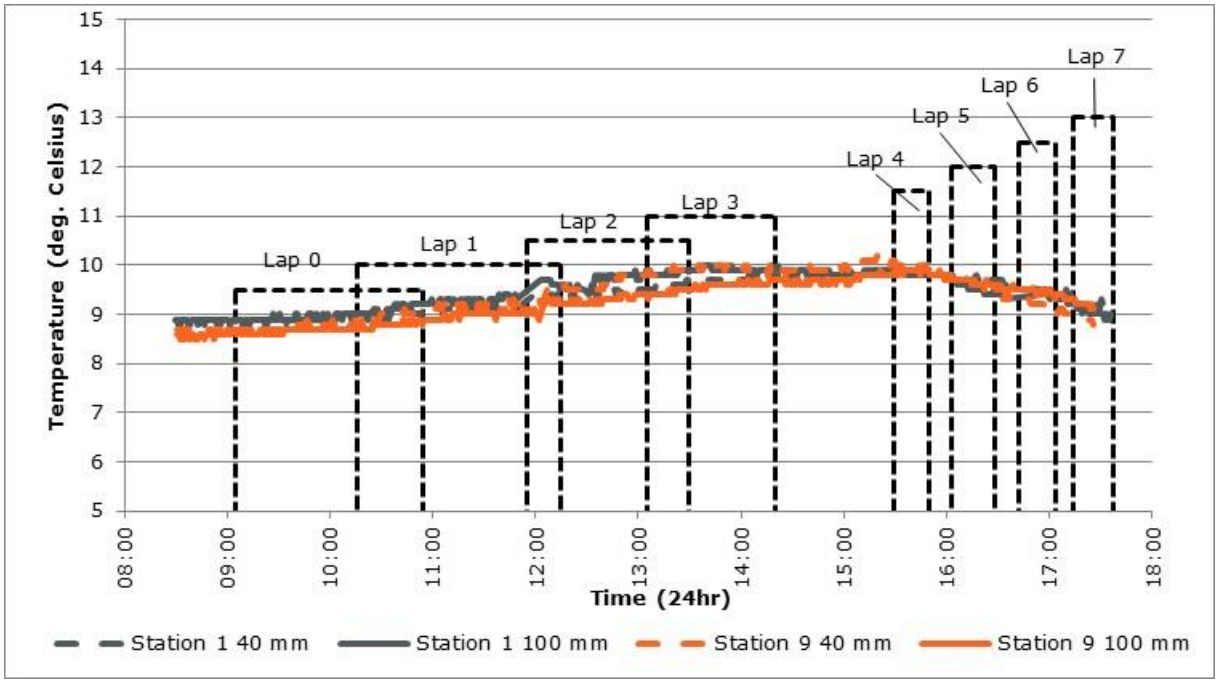

Figure 5.1 Pavement temperatures during main trial day (Day 2)

A summary of the temperature measurements for each test lap are given in Table 5.1 and Table 5.2 for stations 1 and 9 respectively. It can be seen that the 3°C limit was not exceeded on any lap for either pavement temperature depths recorded.

Table 5.1 Pavement temperatures for each lap during Day 2, near station 1

Lap	Start of Lap			End of lap			Duration (hours:mins)	Temperature difference during lap (°C)	
	Time	Temperature (°C)		Time	Temperature (°C)				
		40mm	100mm		40mm	100m		40mm	100mm
0	09:05	8.9	8.9	10:54	9.0	9.2	01:49	0.1	0.3
1	10:16	9.0	9.0	12:15	9.3	9.5	01:59	0.3	0.5
2	11:55	9.1	9.3	13:30	9.7	9.9	01:35	0.6	0.6
3	13:05	9.5	9.8	14:20	9.7	9.9	01:15	0.2	0.1
4	15:29	9.9	9.9	15:50	9.8	9.8	00:21	-0.1	-0.1
5	16:03	9.8	9.8	16:28	9.7	9.4	00:25	-0.1	-0.4
6	16:42	9.6	9.3	17:04	9.5	9.4	00:22	-0.1	0.1
7	17:14	9.4	9.2	17:37	9.2	9	00:23	-0.2	-0.2

Table 5.2 Pavement temperatures for each lap during Day 2, near station 9

Lap	Start of Lap			End of lap			Duration (hours:mins)	Temperature difference during lap (°C)	
	Time	Temperature (°C)		Time	Temperature (°C)				
		40mm	100mm		40mm	100m		40mm	100mm
0	09:05	8.7	8.7	10:54	9.1	8.8	01:49	0.4	0.1
1	10:16	8.8	8.7	12:15	9.5	9.2	01:59	0.7	0.5
2	11:55	9.3	9.1	13:30	9.9	9.5	01:35	0.6	0.4
3	13:05	9.8	9.4	14:20	9.9	9.7	01:15	0.1	0.3
4	15:29	10.1	9.8	15:50	9.9	9.9	00:21	-0.2	0.1
5	16:03	9.8	9.8	16:28	9.5	9.6	00:25	-0.3	-0.2
6	16:42	9.3	9.5	17:04	9.1	9.3	00:22	-0.2	-0.2
7	17:14	9	9.3	17:37	8.8	9.1	00:23	-0.2	-0.2

5.2 Reproducibility results from test laps

In order to evaluate the performance of each machine two laps are chosen from the test set: these laps are denoted lap i and lap ii. In general, the laps chosen for i and ii are laps 1 and 2 respectively (the data from the warm up lap [lap 0] is always discarded). However, when machines do not perform as expected additional laps may be required.

During the warm-up lap machine 6 developed a fault and could not test. Testing with the other machines continued as the machine was inspected. This inspection found that an internal memory card had become corrupted.

The operator for Machine 15 observed an anomaly with their results, and notified the trial marshals. They then identified and fixed the issue before starting lap 2.

After processing lap 1, it was identified that machine 36 was producing values significantly lower than the other machines (i.e. had high FCF values). They were notified of this issue and changed the buffers on the machine before conducting laps 2 and 3.

After fully processing the data from laps 2 and 3, it was seen that the trial criteria for FCF was met by all of the machines which took part (at this point machine 6 was still not operational and had not conducted any laps). The SDDR criteria were met by all but one of the machines which took part (Machine 8).

The crew of Machine 8 were notified of this issue and given an opportunity to examine their machine. During this inspection, an issue was found with geophone 7 which was then replaced. After this repair this machine and Machine 34 conducted repeats of the repeatability testing (see section 4.2).

At this point Machine 6 was repaired and able to conduct testing. Therefore laps 4 and 5 were conducted to assess Machines 6 and 8 (using a selection of the other machines to act as reference). After processing laps 4 and 5 it was found that both machines met the FCF requirements; however Machine 6 did not meet the SDDR requirement. The operators of Machine 6 were notified of this issue and given time to inspect their machine and conduct a further two laps (laps 6 and 7). Machine 6 conducted these laps on their own and the data from the previous two laps were used as reference data. Examination of laps 6 and 7 found that this machine met the FCF requirement but not the SDDR requirement. The operators

for this machine were then notified that they did not meet the criteria for the trial, and testing was stopped.

The FCF and SDDR values derived from each machine's laps are given in Appendix F, Table F.1. The laps chosen for assessment (lap i and ii) were laps 2 and 3 for all machines except for machines 6 and 8. For these machines, the latest available laps were used (6 and 7 for Machine 6, and 4 and 5 for Machine 8).

The results from laps i and ii (prior to any geophone removal) are shown graphically in Figure 5.2 for FCF and Figure 5.3 for SDDR. The vertical bars in these figures indicate the range of values from individual sensors and the filled circles/squares indicate the mean value for all seven sensors.

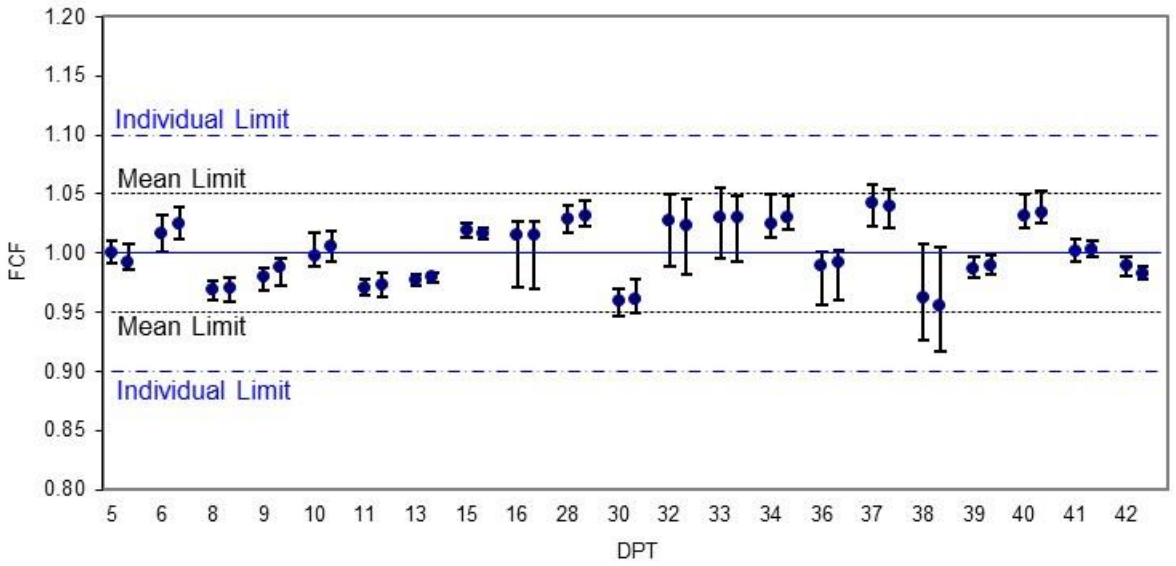

Figure 5.2 Field calibration factors (FCF) for each DPT (main trial day for the chosen test laps, no geophone readings removed)

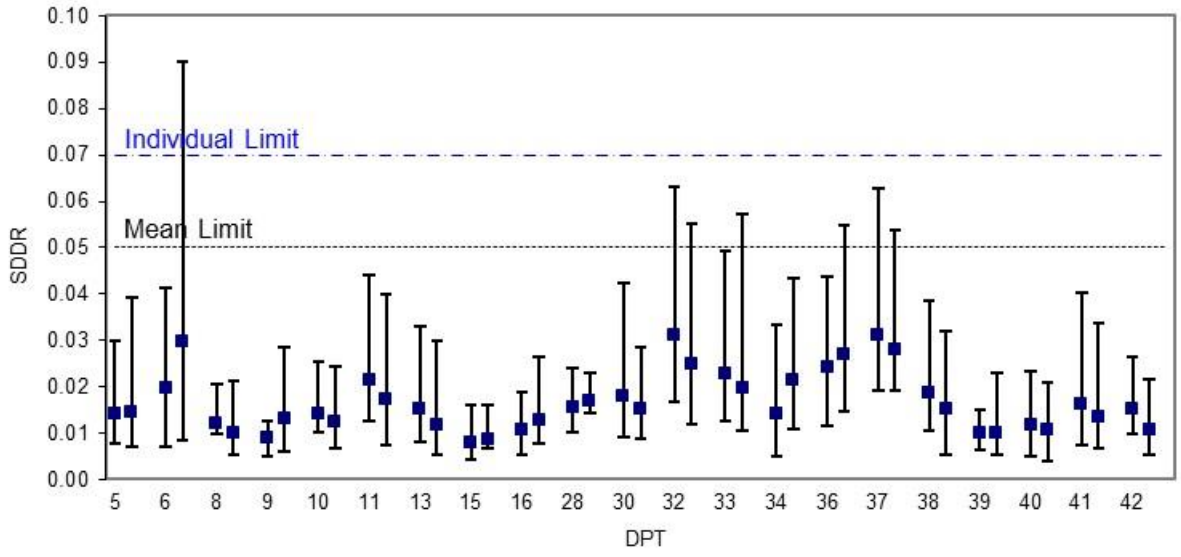

Figure 5.3 Standard deviation of the deviation ratio (SDDR) for each DPT (main trial day for the chosen test laps, no geophone readings removed)

It can be seen from Figure 5.2 that all twenty-one machines passed the trial requirements for Field Calibration Factor (FCF) for both average and individual geophone measurements using the full data set from all seven geophones for each of the twelve stations over the two chosen test laps.

Twenty machines passed the average and individual trial requirements for Standard Deviation of the Deviation Ratio (SDDR) using the full data set from all seven geophones for each of the twelve stations over two test laps (as seen in Figure 5.3). Machine 6 did not meet the SDDR requirement at the trial.

5.2.1 Additional testing for Machine 6

Additional testing was undertaken on 17th December 2014 to re-assess machine 6 following repairs. Following the processing of this data, it was found that this machine now provides acceptable data with regards to SDDR. Further details on this additional testing can be found in Appendix I.

5.3 Distance measurement tests

In order to assess the measurement of distance the measurements provided for laps 0, 1, 2 and 3 were used for each machine. The reference length was 629.75m and the criteria applied to this data are described in 3.3.1. The differences between the trial data and the reference are given in Table 5.3 (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 criteria (6.29m). A machine would fail this test if it could not supply three measured lengths within the criteria.

Table 5.3 Difference between operators' measured values and reference

Machine	Difference between measured distance and reference			
	Lap 0	Lap 1	Lap 2	Lap 3
5	-2.8	-2.8	-2.8	-2.8
6	-0.8	0.3	0.3	0.3
8	-2.8	-1.8	-1.8	-1.8
9	0.3	-0.8	-1.8	-0.8
10	-1.8	-1.8	-1.8	-1.8
11	-0.8	-0.8	-0.8	-0.8
13	-1.8	-1.8	-1.8	-1.8
15	2.3	2.3	2.3	2.3
16	-0.8	0.3	0.3	0.3
28	-1.8	-1.8	-1.8	-1.8
30	-0.8	-0.8	-0.8	-0.8
32	-0.8	-0.8	-0.8	-0.8
33	0.3	0.3	0.3	0.3
34	-0.8	-0.8	-0.8	-0.8
36	0.3	-0.8	0.3	0.3
37	-1.0	-1.1	-1.5	-1.0
38	-0.8	-0.8	-	-0.8
39	1.3	1.3	0.3	0.3
40	-1.8	-1.8	-1.8	-1.8
41	-1.8	-1.8	-1.8	-1.8
42	0.3	0.3	0.3	0.3

It can be seen from this table that all of the machines meet the trial criteria. In addition, 54% of the measurements were within 1m and 100% of the measurements were within 3m.

5.4 OSGR measurements

3-dimensional position data was supplied by 6 of the 21 machines at the trial. Machine 39 revisited the site after the trial and to provide positional data so that it could also be assessed for this criteria. As discussed in section 3.3.2, these devices provide the data in lat/long format. Therefore the data has been converted to OSGR format (eastings and northings) before assessment.

The percentage of the data within 2m and 5m for each of the machines that supplied GPS data is given in Table 5.4. This data is highlighted in bold and red text if the percentage is below 75% for either criteria.

Table 5.4 Assessment of positional data

Machine	Percentage of data that is within x m of the reference (horizontally)		Performance band
	2m	5m	
9	100%	100%	High
30	94%	96%	High
32	*Single non UK coordinate reported for all locations.*		*n/a*
33	*Single non UK coordinate reported for all locations.*		*n/a*
38	**9%**	**50%**	Low
39	100%	100%	High
40	100%	100%	High

5.5 Operator temperature measurements

The DPT operators were asked to use their own equipment to record temperatures from two pre-drilled holes so that the accuracy of temperature collection could be assessed. These holes were located near stations 1 and 9. Both holes were drilled to 100mm depth and the temperatures recorded by the operators are plotted against the data recorded from the adjacent data logger in Figure 5.4 and Figure 5.5.

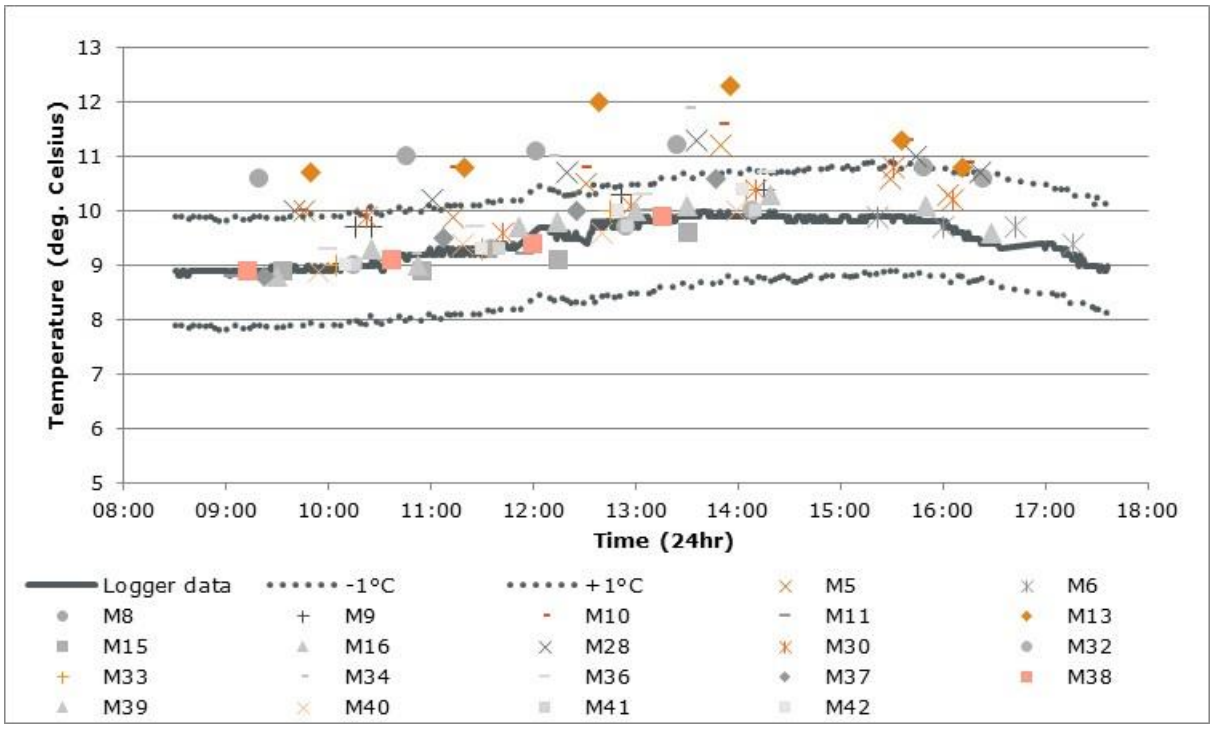

Figure 5.4 Comparison of operators' temperatures and logger temperatures (day 2 near station 1, 100mm depth)

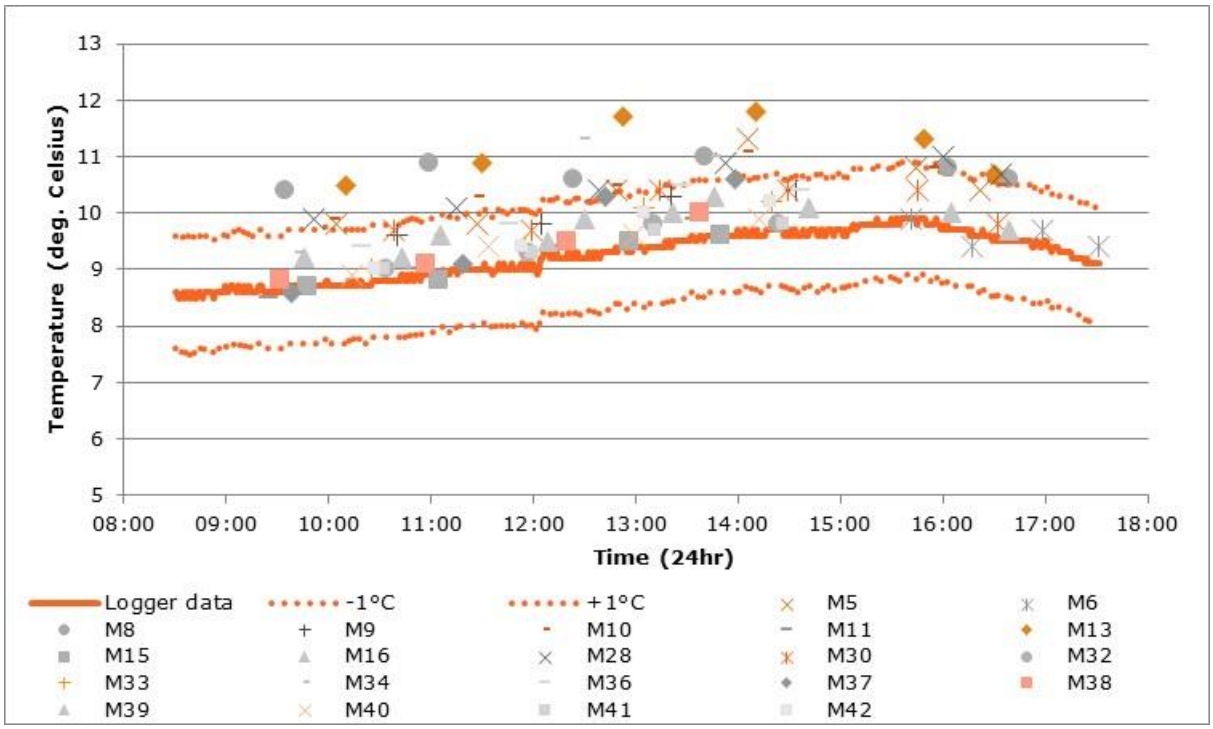

Figure 5.5 Comparison of operators' temperatures and logger temperatures (day 2 near station 9, 100mm depth)

The test criteria for temperature measurement are given in section 3.4, and the machines were initially assessed using the data from laps 0, 1, 2 and 3. The differences and ratings

given are presented in Table 5.5. In the table values are highlighted in bold and red font if the value was more than 1ºC away from the values obtained by the logger.

Table 5.5 Initial assessment of operators measured values (stations 1 and 9)

Machine	Difference between measured temperature and logger (100mm depth)								Rating
	Lap 0		Lap 1		Lap 2		Lap 3		
	1	*9*	1	9	1	9	1	9	
5	**1.1**	**1.1**	0.7	0.8	1	1	**1.2**	**1.7**	Low
6	*Did not participate in laps*								*n/a*
8	**1.7**	**1.7**	**1.9**	**2**	**1.8**	**1.4**	**1.4**	**1.5**	Very Low
9	0.7	0.8	0.7	0.6	0.5	0.8	0.5	0.7	High
10	**1.1**	**1.2**	**1.5**	**1.3**	**1.3**	**1.2**	**1.6**	**1.4**	Very Low
11	-0.1	-0.1	0.1	0.1	-0.1	0.2	0.2	0.4	High
13	**1.7**	**1.8**	**1.6**	**1.9**	**2.2**	**2.3**	**2.3**	**2.2**	Very Low
15	0	0	-0.3	-0.1	-0.4	0.2	-0.3	0	High
16	-0.1	0.5	-0.2	0.7	0.2	0.7	0.2	0.7	High
28	**1.1**	**1.2**	1	**1.1**	**1.2**	**1.1**	**1.4**	**1.3**	Very Low
30	0.9	0.9	0.3	0.7	0.3	1	0.6	0.8	High
32	0	0.2	0	0.2	-0.1	0.4	0.1	0.1	High
33	0	0.3	0.1	0.3	0.2	0.7	0.5	0.5	High
34	-0.2	0.6	0	0.7	**1.3**	**2.1**	**2**	**1.4**	Low
36	0.3	0.6	0.4	0.8	0.5	1	0.8	0.8	High
37	-0.1	-0.1	0.3	0.1	0.5	1	0.7	1	High
38	0	0.2	0	0.2	0.1	0.3	0.1	0.4	High
39	0.3	0.3	0.4	0.2	0.3	0.6	0.3	0.5	High
40	0	0.2	0.1	0.4	-0.2	0.2	0.1	0.3	High
41	0	0.2	-0.1	0.3	-0.1	0.3	0.2	0.1	High
42	0	0.2	0.1	0.3	0.3	0.6	0.5	0.5	High

It can be seen from this table that the majority of the machines achieved the High performance rating. However, four machines (machines 8, 10, 13 and 28) provided data which resulted in the Very Low performance rating and two machines (machines 5 and 34) which achieved a Low performance rating. In all cases the poor performances were caused by the operators measurement being higher than the measurement with the data logger. This is likely to be caused by the operators not leaving the temperature probe in the pavement long enough to stabilise the temperature. The operators of these machines were notified, and were asked to take part in the additional laps conducted to assess machines 6 and 8 (see section 5.2). The operators which provided poor temperature data were then reassessed using laps 2, 3, 4 and 5 (Machine 6 which did not take part in the earlier laps and was assessed using laps 4, 5, 6 and 7). The results of this assessment are shown in Table 5.6.

Table 5.6 Additional assessment of operators measured values (stations 1 and 9)

Machine	Difference between measured temperature and logger (100mm depth)								Rating
	Lap 4		Lap 5		Lap 6		Lap 7		
	1	*9*	1	9	1	9	1	9	
5	0.7	0.9	0.5	0.8	*Did not participate in laps*				Medium
6	0	0	-0.1	-0.3	0.4	0.3	0.2	0.3	High
8	1	1	**1.2**	1	*Did not participate in laps*				Low
10	**1.4**	1	**1.3**	1	*Did not participate in laps*				Low
13	**1.4**	**1.4**	**1.2**	**1.1**	*Did not participate in laps*				Very Low
28	**1.2**	**1.2**	**1.2**	**1.2**	*Did not participate in laps*				Very Low

Following this additional assessment, 2 machines (13 and 28) achieved a very low performance level, 3 achieved a low performance level (8, 10 and 34) and one machine (5) achieved a medium performance level. The remaining 15 machines (6, 9, 11, 15, 16, 30, 32, 33, 36, 37, 38, 39, 40, 41 and 42) achieved a high performance level.

Although not a mandatory criteria it is recommended that the owners of the machines which achieved a low or very low performance level should identify the cause of the differences in temperature values. This could be verification of the calibration of their temperature probe and/or review their temperature measurement procedure.

6 Summary of trial findings

The 2014 UK DPT accreditation trial was held at MIRA on the 11th and 12th November 2014. Twenty-one machines took part in the trial. The key findings of the trial are as follows:

- All twenty-one machines met the mandatory trial requirements for the average and individual geophone Field Calibration Factors (FCF). No machines required any individual geophone readings to be removed to meet the criteria.
- Twenty machines met the mandatory trial requirements for the average and individual geophone Standard Deviation of the Deviation Ratio (SDDR) at the trial. The remaining machine met these requirements in a follow-up assessment. No machines required any individual geophone readings to be removed to meet the criteria.
- All machines met the mandatory trial requirements for elapsed distance measurement.
- Eighteen of the twenty-one machines achieved a high performance rating in all three of the non-mandatory criteria with regards to repeatability. Two machines achieved a medium performance in the standard deviation of normalised deflections criteria, and another achieved a medium performance in the mean load applied criteria (all of these machines achieved high performance in the other repeatability criteria).
- Fifteen of the machines achieved a high performance rating in the non-mandatory temperature measurement criterion. One machine achieved a medium rating, three achieved a low rating and the remaining two were assigned a very low rating.
- Six machines provided GPS data. The machines were only assessed for horizontal reproducibility and three achieved a high rating, and one a low rating. The remaining two machines provided invalid data.

Overall, all twenty-one machines that participated in the November 2014 accreditation trial met the mandatory requirements of the trial.

The outcome of the trial for each machine, against both the mandatory and non-mandatory criteria, is summarised in Appendix G and the overall summary for the trial together with contact details for the appropriate operating company are included in Appendix H.

References

CROW. (2011). *Falling Weight Deflectometer Calibration Guide Report D11-07. Protocol 10. FWD correlation trial.* Ede, The Netherlands: Crow.

Design Manual for Roads and Bridges. (2008, May). *Volume 7 Section 3 Part 2, HD29/08, Data for Pavement assessment*. London: The Stationery Office.

Gershkoff, D., Viner, H., & Heath, V. (1999). *Preliminary Falling Weight Deflectometer Correlation Trial - TRL 1998 (PR/CE/51/99).* Wokingham: TRL.

Acknowledgements

The author wishes to thank the operators of the DPT devices for their co-operation in the accreditation process. The author is also grateful to Brian Ferne who carried out the technical review of this report, and to George Beard, Marie Militzer and Pete Sanders for their assistance with the trial.

Appendix A Machine details table

Table A.1 Final Machine details

ID	Owner	Make, model and serial number	Trailer or vehicle mounted?	No. of weights/ buffers per side	Plate diameter and type	Date of last tower calibration	Date of last dynamic calibration	Date of last manufacturer calibration
5	URS Ltd.	Dynatest HWD 8082 SN 050	Trailer	2/5	2-way Segmented	15/08/2014	10/11/2014	16/10/2014
6	PMS Ltd.	Dynatest HWD 8082 SN 018	Trailer	1/5	Solid	**29/10/2014**	**29/10/2014**	30/10/2014
8	URS Ltd.	Dynatest FWD 8002 SN 028	Trailer	6/3	2-way Segmented	03/04/2014	10/11/2014	19/09/2014
9	PMS Ltd.	Dynatest 8002 FWD SN 136	Trailer	4/2	2-way Segmented	08/10/2014	08/10/2014	03/11/2014
10	URS Ltd.	Dynatest FWD 8002 SN 192	Trailer	6/3	2-way Segmented	14/08/2014	10/11/2014	03/10/2014
11	Forth Bridge constructors JV	Dynatest FWD 8002 SN 187	Trailer	6/3	Solid	**29/07/2014**	**06/11/2014**	29/07/2014
13	URS Ltd.	Dynatest HWD 8082 SN 029	Trailer	2/5	Solid	04/04/2014	10/11/2014	10/09/2014
15	CET Infrastructure	Dynatest FWD 8002 SN 203	Trailer	6/3	2-way Segmented	**June 2014**	**June 2014**	June 2014
16	PTS	Dynatest FWD 8002 SN 214	Trailer	5/2	2-way Segmented	10/11/2014	**10/11/2014**	20/08/2014
28	Pulse surveying Ltd.	Dynatest FWD 8002 SN 271	Trailer	4/2	Solid	**September 2013**	**22/10/2014**	**29/08/2014**
30	PMS Ltd.	Dynatest 8002 FWD SN 173	Trailer	5/2	Solid	**29/08/2014**	**29/08/2014**	14/04/2014
32	ALC (MoD)	Dynatest HWD 8082 SN 069	Trailer	1/2	Solid	**16/09/2014**	**16/09/2014**	16/09/2014
33	ALC (MoD)	Dynatest HWD 8082 SN 070	Trailer	1/2	Solid	**24/10/2014**	**24/10/2014**	24/10/2014

ID	Owner	Make, model and serial number	Trailer or vehicle mounted?	No. of weights/ buffers per side	Plate diameter and type	Date of last tower calibration	Date of last dynamic calibration	Date of last manufacturer calibration
34	PTS	Dynatest HWD 8082 SN 108	Trailer	1/2	4-way Segmented	10/11/2014	**10/11/2014**	10/10/2014
36	TestConsult Ltd.	Grontmij FWD PRI2500 SN 0608¬-303	Trailer	3/8	2-way Segmented	7/11/2014	18/11/2013	22/11/2013
37	Stanger Testing	Dynatest FWD 8002 SN 352	Trailer	6+1/3	4-way Segmented	8/11/2014	**08/11/2014**	22/09/2014
38	Milestone Pavement Technologies	Grontmij FWD PRI1500 SN 1111-448	Trailer	3/8	4-way Segmented	01/09/2014	**09/10/2014**	02/09/2014
39	TRL	Dynatest FWD 8002 SN 388	Trailer	6/3	Segmented	19/09/2014	07/11/2014	08/04/2014
40	Dynatest	Dynatest FWD 8012 SN 002	Trailer	?/3	4-way Segmented	-	**28/11/2014**	07/10/2014
41	ALC (MoD)	Dynatest HWD 8082 SN 145	Trailer	1/2	4-way Segmented	-	**10/11/2014**	27/03/2014
42	ALC (MoD)	Dynatest HWD 8082 SN 149	Trailer	1/2	4-way Segmented	-	**10/11/2014**	17/09/2014

* Provided dates for when the calibration took place but no evidence provided of the calibration.

Appendix B Example photographs

Figure B.1 Dynatest 8002 FWD

Figure B.2 Dynatest 8082 HWD

Figure B.3 Grontmij Primax 2100 HWD

Figure B.4 Grontmij Primax 1500 HWD

Appendix C Construction details for 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 Dynamic Plate Test device 2014 Accreditation trial - Instructions to operators

The 2014 FWD accreditation trial is carried out as a prerequisite to operating these devices under Highways Agency contracts. The objective of the trial is to identify machines that produce results within a specific tolerance of the fleet average. The trial has been designed to ensure that the results of the trial are scientifically robust, and impartial. This document acts as an outline to the trial and provides operators with instructions for the trial activities. All trial attendees must read and understand this document before attending the trial.

Please e-mail your confirmation of attendance, names of all persons, registrations of all vehicles, and the completed machine checks form(s) to:

'The Auditor' C/o Roger Fairclough, Highways Agency, e-mail roger.fairclough@highways.gsi.gov.uk

As highlighted in Highways Agency e-mail dated 27th October 2014, there will be a participation fee of £500 for each machine at the 2014 FWD accreditation trial. This will be payable to the Agency's appointed Auditor before any certificates can be awarded.

D.1 Prior to trial

D.1.1 Machine checks

Please perform your routine inspections and check over your machine to reduce the chances of any issues occurring during the trial. You will be supplied with inspection sheets which will need to be completed and returned to the Auditor prior to the trial. These sheets will form the basis of the machine inspections conducted on day 1 of the trial.

D.1.2 Geophone positions and machine set up

The operation of the FWDs will be as described in HD29/08 of the DMRB using the flexible and flexible composite set up (i.e. geophones at 0, 300, 600, 900, 1200, 1500 and 2100). **Note this is a different set-up from previous trials.**

Please make sure that your geophones are in the correct positions prior to arrival. In addition please ensure that only the data from these seven geophones will be present in your F20 files (and the geophones are in the correct order).

Further details on machine set-up can be seen in D.8.

D.1.3 Preparation for Repeatability testing

The Repeatability testing part of the trial (on day 1) requires the application of loads of 50±5kN with load targeting or "seeking" turned **off**. Therefore it may be necessary for crews to carry out some initial tests prior to the trial to identify the test procedure/test settings to achieve this result. If the average load for the drops is not 50±5kN then the machine will be deemed to have failed the repeatability criteria.

D.1.4 Trial attendee names

To make accessing the MIRA site as smooth as possible please provide the names of all persons (and registrations of all vehicles) attending the trial beforehand. These will be passed to MIRA security and used to produce yellow test track access permits.

D.2 Trial Outline

The trial will last for 3 days and takes place between the 11th and 13th of November 2014. The trial activities have been split as follows:

- **Day 1** – Machine inspection, distance calibration, a pre-main testing Reproducibility lap and Repeatability testing (1 lap).
- **Day 2** – Reproducibility laps (at least 2 full laps).
- **Day 3** – Contingency day for repeat testing.

D.3 General requirements during trial

D.3.1 Safety briefing

On the morning of each day a safety briefing will be given detailing the site rules. If any of these rules are broken then trial marshals will give **one** verbal warning to relevant parties. **If the behaviour persists then the relevant parties will be escorted from the site and they will not be able to take part in the remainder of the trial**.

D.3.2 Cameras

Please note MIRA **do not allow cameras on site** without prior written consent. Any cameras will have to be left at the gatehouse, camera phones have to be declared and (tamper proof) stickers will be placed over the camera lens (so as to allow the phones to be used). **Any person found to be in conflict with these rules will be immediately evicted from the site**.

D.3.3 Escorting of vehicles

Escorting of vehicles around the proving ground by trial marshals is essential. It is therefore important that particular care is taken when moving around the site.

D.3.4 Speed limits on site and PPE

The nature of FWD testing means that there will often be staff walking around the test sections. Therefore a **10 mph speed restriction will be imposed for the test lengths**. The extent of the site which will have this speed restriction in place will vary depending on the testing being conducted and will be described in the test description parts of this document. If you are unsure of the extents of the restriction please ask a trial marshal.

All staff must wear high visibility jackets when walking on the twin straights or in the manoeuvres area.

D.3.5 Data format, GPS and automatic temperature measurement

Survey data should be supplied as ".F20" files, further details on naming conventions for the trial can be found in D.9.

If your device has an integrated GPS system and/or contactless sensors for measurement of air and surface temperature at each test point then please have these devices switched on and recording at each test location during the test laps. Location information must be provided in OSGR format and must correspond to the centre of the loading plate. The system must be capable of providing all results in the F20 file. This data will not be formally assessed against test criteria however the results will be analysed and the findings will be used to help determine future test criteria (the results/findings will be discussed in the trial report).

D.4 Day 1 (Tuesday 11th November) - Machine inspection, distance calibration and initial testing

D.4.1 Arrival at MIRA

Please **arrive at the MIRA site by 09:00**, directions to MIRA are provided in D.7.

On arrival, sign in with MIRA security at the Number 1 gatehouse. You will then be directed to the manoeuvres area.

Once in the manoeuvres area please see the trial marshal at the registration desk. Here you shall be asked to sign a log in sheet and will be given a USB data drive and participant pack with machine numbers and the necessary paperwork. Please read **all** the paperwork. An introductory briefing will be given once all machines have arrived.

Figure 6: Access to MIRA

D.4.2 Machine inspections

Machine inspections of the devices will be carried out on a "first come first served basis" and may take place before or after the introductory briefing (depending on arrival times). The machine inspections will follow the format of the machine check list supplied prior to the trial (see section D.1.1).

D.4.3 Distance calibration and initial reproducibility test (twin straights)

Once the inspections have been completed you will be escorted to the twin straights by an escort vehicle. When the escort vehicle stops on the twin straights, stop behind them (the blue area in Figure 7). The escort vehicle will then wait until all machines have entered the twin straights.

Once all of the machines have entered the test track you will be cleared to perform a **distance calibration** of your machine using cones A and B which are 400 m apart. After completion of the distance calibration, proceed with the initial reproducibility test using cones 1-12. **Only start testing when instructed to do so**.

During this testing a 10mph speed limit will be in place from the start cone to cone 12.

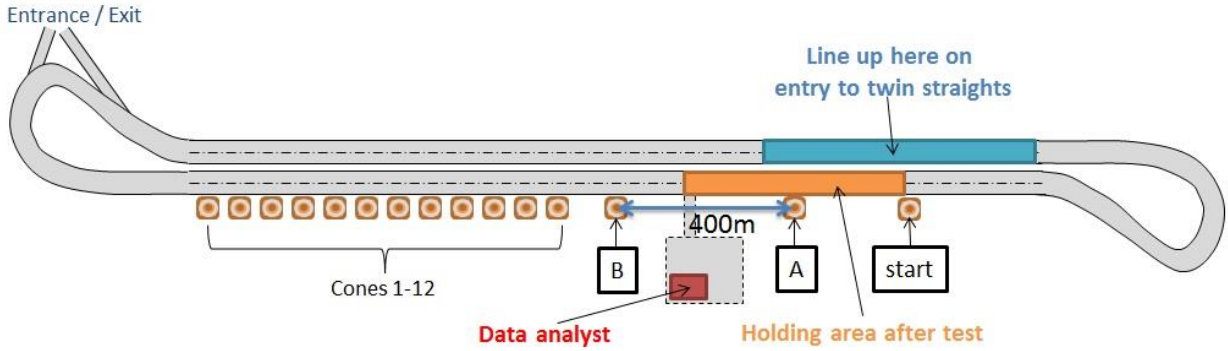

Figure 7: Distance Calibration and initial reproducibility test

The **reproducibility** testing is as follows:

- 5 drops at stations 1 to 12
- 50±5kN load
- Load targeting ("seeking") may be used
- Filename: *MM*FAM.F20, where: *MM* = Machine Trial Number (see D.9)

On completion of the pre main testing lap stop in the holding area (orange area in Figure 7) and hand in your data to the data analyst. The data analyst will be located in the location shown on Figure 7. Note this data will not form part of the trial data and is instead used to help identify major issues. This data will be processed during the repeatability testing and you will be notified if any large anomalies become apparent.

If you encountered any issues with the distance calibration or reproducibility lap, please notify a marshal who will arrange for you to redo the calibration or testing at a suitable time.

D.4.4 Repeatability

When you have supplied your data from the reproducibility lap and the marshal has cleared you to start, complete one repeatability test pass.

During this testing a 10mph speed limit will be in place from the start cone to cone 13 (excluding the banked bend).

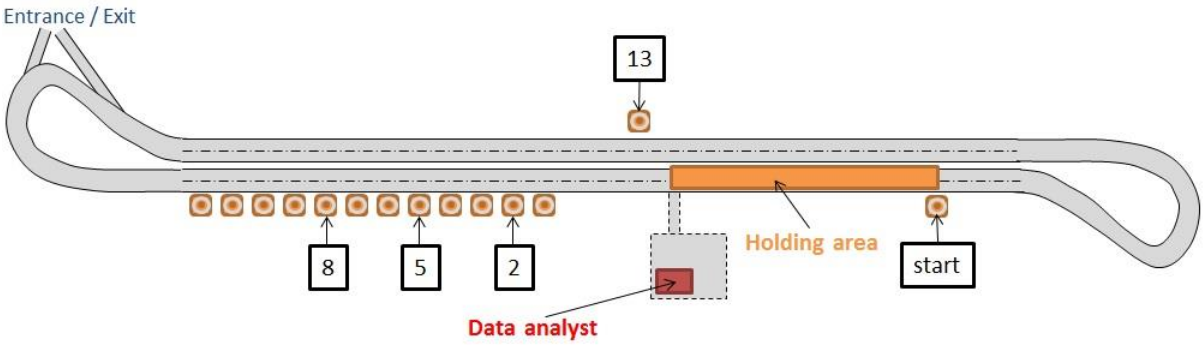

Figure 8: Repeatability lap

The **repeatability** testing is as follows:

- 12 drops at stations 2, 5, 8 and 13
- 50±5kN load
- Load targeting ("seeking") may **not** be used
- Filename: *MM*REPEAT.F20, where: *MM* = Machine Trial Number (see D.9)

On completion of the repeatability test stop in the holding area (orange area in Figure 8) and hand in your data to the data analyst. The marshal will then inform you if any issues have been identified from the reproducibility data (the first lap) and clear you to leave the site (unless an additional pass is required).

D.5 Day 2 (Wednesday 12th November) – Main test day

Please **arrive at the MIRA site by 09:00**. If any issues with your machine were highlighted after the first day please make sure they are fully rectified before 09:00. On arrival, go to the manoeuvres area where you will be met by a trial marshal. Please sign in at the reception desk.

After the morning briefing you will be escorted to the twin straights by an escort vehicle. Stop in the holding area as shown in Figure 9.

During this testing a 10mph speed limit will be in place from the start cone to cone B (excluding the banked bend).

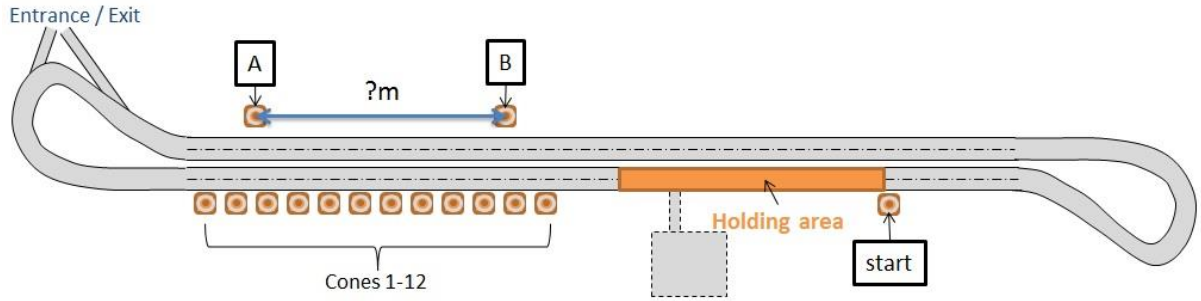

Figure 9: Main day testing

Once you have been cleared for testing, conduct a warm-up lap followed by 2 test laps. This reproducibility testing is as follows:

- Testing at stations 1 to 12
- 5 drops at each of the twelve stations
- 50±5kN load
- Load targeting ("seeking") may be used
- Filename: *MMLL*ACC.F20, where: *MM* = Machine Trial Number and *LL* = Run number (see D.9)
- Temperatures collected using the 100mm depth supplied holes (near cones 2 and 6)
- Distance between A and B measured
- Hand in data after completion of each run (temperatures and distances should be recorded on the supplied pieces of paper and handed in at the end of the day)

After completion of the laps and initial processing of the test data, you will be notified if additional laps are required on this day and/or if the reserve day is required.

D.6 Day 3 (Thursday 13th November) –Contingency day

The format of the contingency day will depend on what additional testing is required. It is likely to involve some combination of days 1 and 2. If the contingency day is required, then a plan will be constructed and you will be notified of what is required.

D.6.1 Reporting of results

The required criteria for receiving accreditation are laid out in the issued document "Accreditation and Quality Assurance of Dynamic Plate Test Devices".

The reporting of trial results will be implemented as below:

- End of trial day 1 – Operators shall be informed if any machine is producing values which indicate a serious machine fault, such as a component failure.
- End of trial day 2 – Operators shall be informed of initial findings and if the reserve day is required.
- Within one week of the trial – Operators will be informed via e-mail whether their machine is an outlier with regards to reproducibility measurements.
- Within 2-3 weeks of the trial - Trial certificates will be e-mailed – *this will be dependent on payment of the participation fee to the Auditor*. These certificates will detail the pass/fail status of the machine with regards to each of the trial criteria.

D.7 Directions to MIRA

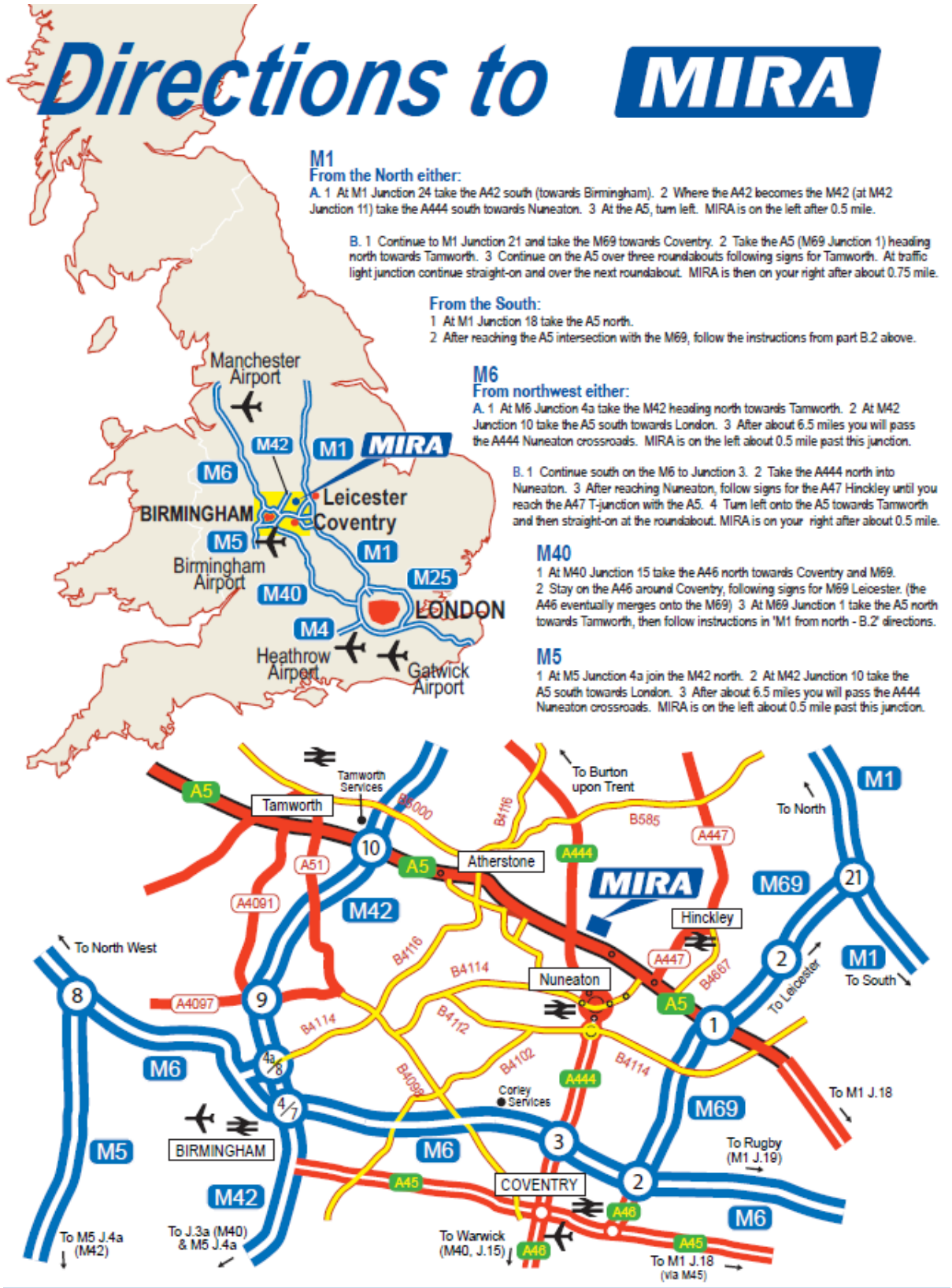

Figure 10: MIRA location

D.8 FWD set-up

Please ensure that your machine is set up as follows:

- geophone spacings: 0, 300, 600, 900, 1200, 1500 and 2100mm **only**;
- standard 300mm diameter plate.
- it is recommended that a rear extension bar is **not** fitted

All testing will take place at the standard load of **50kN** and we strongly recommend that if you have a smoothing facility, you activate it.

Please ensure that time histories are recorded for all tests. You will be provided with a suitably-sized USB stick for delivery of data for processing.

To facilitate the analysis of the data, data should be provided in standard metric ".F20" format.

Please ensure you bring along a calibrated temperature probe (with calibration certificate) capable of measuring to a pavement depth of 100mm.

The accuracy of the location referencing of your machine will be assessed. Please ensure the DMI or odometer (and GPS system if fitted) is working correctly.

These FWD set-up requirements are summarised as follows:

Number of geophones	7 only
Geophone spacing	300mm
Load platen	300mm diameter
Load	50kN
Smoothing (if available)	ON
Extension bar	Removed
Data output	Standard metric
Time history data	To be recorded

D.8.1 Repeatability Testing

The Repeatability Testing will require 12 drops at each of 4 marked test stations. Only the last 10 drops will be used in the analysis. Load targeting ("seeking") may **NOT** be used for this phase of the testing.

Please ensure that the FWD is suitably configured for this test arrangement.

D.8.2 Reproducibility Testing (Including Familiarisation Lap)

The Reproducibility Testing (and check lap) will require 5 drops at each of 12 marked test stations. Only the last 4 drops will be used in the analysis. Load targeting ("seeking") may be used.

Please ensure that the FWD is suitably configured for this test arrangement.

D.9 Naming format for data files

Please note the requirements are different for different aspects of the accreditation trial

Day 1

Familiarisation Lap: *One lap, 12 stations, 5 drops per station. Seek allowed.*
Results will be saved as a separate data file defined as follows: **Filename: MM**FAM.F20 Where: ***MM*** **=** Machine Trial Number
Each test point/station within the file has a letter S (S = 1-12). Each station tested will be labelled using the numeric or chainage setting facility of the FWD software.
EXAMPLE: Machine 9, Familiarisation Lap should be saved as: **09FAM.F20**

Repeatability Test: *One lap, four stations, 12 drops per station. No seek to be used.*
Results will be saved as a separate data file defined as follows: **Filename: MM**REPEAT.F20 Where: ***MM*** **=** Machine Trial Number
Each test point/station within the file has a letter **S** (S = 2, 5, 8 or 13). Each station tested will be labelled using the numeric or chainage setting facility of the FWD software.
EXAMPLE: Machine 37, Repeatability test should be saved as: **37REPEAT.F20**

Day 2

Main Accreditation Trial*: Minimum 3 laps, 12 stations, 5 drops/ station. Seek allowed.*
Results *from each lap* will be saved as a separate data file according to the following naming format: **Filename:** *MMLL*ACC.F20 Where: **MM =** Machine Trial Number, and **LL =** Run number
Run Numbers Warm up lap: 00 Lap 1: 01 Lap 2: 02 Lap 3: 03 …etc
Each test point/station within the lap has a letter S (S = 1 to 12). Each station tested will be labelled using the numeric or chainage setting facility of the FWD software.
EXAMPLE: Machine 2, lap 1 should be saved as: **0201ACC.F20**

Appendix E Repeatability trial data

A.1 Machine 5

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	61	54	48	42	37	31	21	0.4	0.2	0.3	0.2	0.1	0.2	0.2
5	328	276	198	131	84	52	28	1.5	1.1	0.8	0.5	0.4	0.3	0.3
8	201	179	147	112	84	60	32	0.5	0.4	0.3	0.2	0.2	0.1	0.1
13	109	97	83	68	56	45	29	0.5	0.5	0.3	0.4	0.3	0.5	0.7

A.2 Machine 6

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	65	55	49	44	37	33	21	0.4	0.3	0.3	0.2	0.2	0.5	0.2
5	347	291	206	137	87	57	30	1.0	0.7	0.5	1.0	0.9	0.3	1.9
8	212	186	152	117	87	64	35	0.4	0.3	0.3	0.1	0.5	0.6	0.5
13	116	103	89	74	61	49	30	0.4	0.3	0.5	0.4	0.8	1.4	0.7

A.3 Machine 8 run 1

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	65	53	50	50	42	33	22	0.2	0.2	0.3	0.3	0.2	0.1	0.1
5	355	300	213	144	89	61	32	1.0	2.9	1.2	1.0	1.1	1.2	**2.4**
8	216	193	155	121	88	65	35	0.4	0.4	0.3	0.3	0.2	0.1	0.3
13	119	108	92	79	62	50	31	0.6	**3.0**	**2.1**	**3.3**	0.8	0.5	0.9

A.4 Machine 8 run 2

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	65	57	54	47	40	33	23	0.4	0.4	1.8	0.8	1.0	0.4	0.2
5	373	313	216	146	90	58	33	1.2	2.4	0.6	0.8	0.3	0.5	0.1
8	219	198	156	121	93	65	34	0.8	0.6	0.6	0.8	0.3	0.2	0.1
13	65	57	54	47	40	33	23	0.4	0.4	1.8	0.8	1.0	0.4	0.2

A.5 Machine 9

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	63	56	49	44	38	32	22	0.3	0.4	0.5	0.3	0.3	0.2	0.5
5	340	292	206	138	88	57	32	1.0	1.0	0.6	0.2	0.3	0.2	0.4
8	206	183	148	115	85	63	32	0.5	0.5	0.3	0.3	0.9	0.8	0.8
13	113	106	89	84	63	53	27	0.3	0.5	0.2	0.6	0.3	0.5	0.8

A.6 Machine 10

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	64	54	50	43	37	31	22	0.1	0.2	0.1	0.1	0.2	0.1	0.1
5	342	285	203	135	87	55	31	1.0	0.7	0.4	0.3	0.4	0.2	0.2
8	210	185	148	116	85	60	33	0.5	0.3	0.3	0.2	0.1	0.1	0.1
13	118	104	89	74	59	48	29	0.3	0.2	0.2	0.3	0.5	0.1	0.2

A.7 Machine 11

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	66	59	52	46	40	34	24	0.2	0.3	0.3	0.1	0.5	0.1	0.3
5	345	298	210	138	87	55	29	0.5	0.7	0.5	0.5	0.4	0.1	0.1
8	215	194	158	121	90	65	34	0.4	0.3	0.3	0.3	0.5	0.2	0.3
13	119	106	91	73	61	51	30	0.4	0.2	0.2	0.3	0.2	0.4	0.7

A.8 Machine 13

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	63	55	50	44	38	33	23	0.6	0.5	0.3	0.3	0.3	0.2	0.2
5	346	284	202	134	86	54	28	1.1	0.6	0.5	0.3	0.2	0.2	0.3
8	210	187	152	118	87	63	33	0.8	0.8	0.6	0.4	0.3	0.3	0.3
13	111	103	88	74	61	49	31	1.6	0.3	0.4	0.3	0.2	0.2	0.1

A.9 Machine 15

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	62	55	49	44	38	31	22	0.1	0.0	0.1	0.3	0.1	0.1	0.1
5	342	292	205	136	86	54	30	0.7	0.6	0.3	0.2	0.2	0.1	0.2
8	207	186	152	117	87	61	32	0.3	0.3	0.1	0.1	0.1	0.1	0.1
13	112	102	88	73	60	47	28	0.6	0.1	0.2	0.1	0.1	0.3	0.1

A.10 Machine 16

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	62	54	48	43	37	31	23	0.3	0.4	0.5	0.1	0.5	0.4	0.5
5	356	289	202	135	87	55	33	0.6	0.7	0.7	0.4	0.4	0.4	0.1
8	206	182	149	116	86	61	34	0.4	0.5	0.4	0.3	0.3	0.3	0.3
13	120	110	94	80	63	49	34	0.4	0.3	0.4	0.4	0.3	0.4	0.4

A.11 Machine 28

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	61	54	49	43	36	31	21	0.5	0.1	0.2	0.1	0.1	0.1	0.4
5	342	289	206	136	86	56	31	0.6	0.4	0.2	0.2	0.3	0.2	0.1
8	204	182	150	115	84	62	33	0.3	0.3	0.3	0.1	0.2	0.1	0.4
13	112	101	88	73	59	46	29	0.2	0.2	0.3	0.4	0.2	0.3	0.1

A.12 Machine 30

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	67	58	53	47	41	34	24	**2.7**	0.2	0.3	0.1	0.3	0.1	0.3
5	361	297	213	141	89	56	31	0.9	1.2	0.3	0.9	0.1	0.2	0.5
8	218	192	158	122	91	65	34	0.4	0.2	0.2	0.2	0.2	0.1	0.2
13	127	109	95	79	64	51	32	0.4	0.2	0.2	0.5	0.2	0.3	0.5

A.13 Machine 32

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	61	53	49	42	36	31	21	0.7	0.4	0.5	0.4	0.5	0.3	0.0
5	342	295	209	141	90	61	33	1.0	0.9	0.3	0.7	0.5	0.8	0.5
8	204	183	149	116	85	63	33	0.5	0.7	0.4	0.8	0.5	0.4	0.9
13	111	100	87	72	58	47	29	0.8	0.5	0.5	0.5	0.4	0.5	0.5

A.14 Machine 33

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	61	54	48	43	37	30	21	0.5	0.2	0.5	0.1	0.5	0.6	0.7
5	339	296	207	138	90	56	32	0.7	0.6	0.7	0.2	0.1	0.4	0.5
8	205	183	148	114	85	61	33	0.2	0.4	0.2	0.6	0.1	0.5	0.3
13	116	105	89	73	59	46	28	0.6	0.5	0.3	0.1	0.4	0.4	1.2

A.15 Machine 34 run 1

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	55	54	48	43	36	31	20	**3.3**	0.5	0.5	0.4	0.5	0.6	0.5
5	351	300	212	141	88	58	32	**7.3**	**5.7**	**4.0**	**2.8**	1.5	0.9	0.7
8	198	185	150	116	85	63	33	2.2	1.1	0.7	0.8	0.5	0.7	1.2
13	119	108	94	79	64	52	34	**2.7**	0.7	0.9	0.6	0.4	0.6	0.6

A.16 Machine 34 run 2

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	58	53	48	43	36	30	21	0.9	0.3	0.5	0.2	0.4	0.7	0.1
5	355	298	210	139	86	56	28	2.1	1.5	1.0	0.7	0.5	0.6	0.4
8	203	184	151	117	85	62	31	0.9	1.0	1.0	0.6	0.7	0.4	0.6
13	102	102	87	73	58	46	28	**2.7**	0.6	0.4	0.3	0.3	0.3	1.1

A.17 Machine 36

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	64	52	47	41	36	31	22	1.1	0.2	0.2	0.4	0.2	0.2	0.2
5	314	266	189	126	78	50	26	1.0	0.5	0.4	0.2	0.2	0.1	0.1
8	200	175	142	111	81	59	31	1.0	0.3	0.3	0.3	0.2	0.2	0.1
13	113	98	84	71	57	46	29	0.5	0.1	0.1	0.1	0.1	0.1	0.1

A.18 Machine 37

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	61	54	48	42	37	31	20	0.1	0.4	0.3	0.1	0.1	0.6	0.0
5	344	296	210	139	90	57	32	0.7	0.4	0.4	0.3	0.5	0.4	1.2
8	206	183	149	115	86	61	32	0.4	0.3	0.6	0.2	0.5	0.1	0.3
13	114	102	88	72	59	46	28	0.4	0.4	0.2	0.2	0.4	0.3	0.3

A.19 Machine 38

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	67	59	53	48	41	36	23	0.3	0.3	0.3	0.2	0.2	0.2	0.2
5	351	298	214	143	90	58	28	0.8	0.7	0.6	0.5	0.4	0.3	0.3
8	218	195	160	125	92	68	34	0.4	0.3	0.4	0.4	0.4	0.3	0.3
13	122	110	95	81	66	54	31	0.3	0.3	0.3	0.3	0.3	0.2	0.2

A.20 Machine 39

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	65	56	50	44	38	32	23	0.5	0.3	0.1	0.1	0.4	0.3	0.3
5	350	301	214	142	91	57	32	1.1	0.5	0.5	0.3	0.5	0.4	0.1
8	209	187	153	118	88	64	34	0.7	0.5	0.5	0.6	0.5	0.5	0.6
13	120	107	90	74	62	50	31	0.4	0.3	0.3	0.5	0.4	0.2	0.5

A.21 Machine 40

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	61	55	49	44	38	31	22	0.2	0.1	0.1	0.1	0.1	0.0	0.1
5	340	286	200	134	83	53	28	0.8	0.5	0.3	0.5	0.2	0.3	0.4
8	207	185	151	115	85	61	31	0.2	0.3	0.2	0.1	0.1	0.1	0.2
13	115	104	90	75	61	48	29	0.1	0.3	0.3	1.0	0.2	0.3	0.1

A.22 Machine 41

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	64	56	50	44	38	32	22	0.3	0.3	0.4	0.3	0.4	0.6	1.2
5	365	295	206	137	86	56	31	1.0	0.7	0.5	0.5	0.4	0.5	0.7
8	211	190	154	121	88	63	33	0.5	0.5	0.4	0.8	0.4	0.5	0.5
13	116	106	90	78	63	50	33	0.6	0.6	0.4	0.5	0.6	0.6	0.1

A.23 Machine 42

Station	Mean of the normalised deflection (µm)							Standard deviation of the normalised deflections (µm)						
	D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
2	66	58	52	46	39	33	23	0.5	0.5	0.3	0.3	0.3	0.4	0.3
5	370	298	209	137	87	54	32	1.3	0.7	0.5	0.4	0.1	0.3	0.5
8	218	193	157	121	90	65	34	0.6	0.2	0.3	0.6	0.3	0.6	0.0
13	118	106	91	76	63	49	31	0.5	0.3	0.5	0.2	0.2	0.1	0.4

Appendix F Reproducibility trial data

Note: In the table bold red text indicates that the value is outside acceptable limits. Data from laps disregarded in the accreditation analysis are shown in italics

Table F.1 2014 All trial data during main trial day (all laps, and no geophones removed)

DPT ID	Lap	Lap Used	Field Calibration Factor								Standard Deviation of Deviation Ratio (SDDR, µm)							
			D1	D2	D3	D4	D5	D6	D7	mean	D1	D2	D3	D4	D5	D6	D7	mean
5	*0*	*N*	*0.991*	*0.997*	*0.989*	*1.002*	*1.004*	*1.006*	*1.016*	*1.001*	*0.010*	*0.011*	*0.008*	*0.009*	*0.019*	*0.024*	*0.028*	*0.015*
	1	*N*	*0.989*	*0.993*	*0.985*	*0.996*	*0.997*	*1.002*	*0.974*	*0.991*	*0.017*	*0.010*	*0.011*	*0.009*	*0.009*	*0.016*	*0.042*	*0.016*
	2	Y	0.996	0.999	0.992	1.001	0.997	1.008	1.011	1.001	0.010	0.008	0.010	0.009	0.012	0.020	0.030	0.014
	3	Y	0.992	0.991	0.986	0.995	0.986	0.990	1.008	0.993	0.007	0.007	0.009	0.011	0.014	0.015	0.039	0.015
	4	*N*	*1.006*	*1.004*	*0.999*	*1.006*	*1.002*	*1.012*	*1.007*	*1.005*	*0.009*	*0.010*	*0.010*	*0.012*	*0.014*	*0.015*	*0.027*	*0.014*
	5	*N*	*1.010*	*1.001*	*0.999*	*1.002*	*0.997*	*0.993*	*1.013*	*1.002*	*0.007*	*0.008*	*0.008*	*0.009*	*0.012*	*0.015*	*0.029*	*0.012*
6	*4*	*N*	*1.025*	*1.019*	*1.022*	*1.032*	*1.027*	*0.982*	*1.097*	*1.029*	*0.024*	*0.010*	*0.011*	*0.020*	*0.027*	*0.039*	*0.092*	*0.032*
	5	*N*	*1.010*	*1.016*	*1.017*	*1.021*	*1.022*	*0.986*	*1.117*	*1.027*	*0.027*	*0.012*	*0.014*	*0.020*	*0.038*	*0.064*	*0.113*	*0.041*
	6	Y	1.007	1.021	1.027	1.032	1.018	1.008	1.001	1.016	0.018	0.007	0.010	0.016	0.021	0.024	0.041	0.020
	7	Y	1.011	1.021	1.025	1.025	1.020	1.031	1.039	1.025	0.018	0.010	0.008	0.016	0.020	0.046	0.090	0.030
8	*0*	*N*	*0.958*	*0.951*	*0.936*	*0.929*	*0.960*	*0.942*	*0.974*	*0.950*	*0.014*	*0.056*	*0.096*	*0.046*	*0.016*	*0.041*	*0.020*	*0.041*
	1	*N*	*0.964*	*0.947*	*0.961*	*0.941*	*0.941*	*0.951*	*1.018*	*0.960*	*0.010*	*0.042*	*0.026*	*0.031*	*0.038*	*0.033*	*0.088*	*0.038*
	2	*N*	*0.970*	*0.964*	*0.970*	*0.948*	*0.964*	*0.955*	*1.080*	*0.979*	*0.009*	*0.017*	*0.020*	*0.032*	*0.032*	*0.052*	*0.101*	*0.038*
	3	*N*	*0.962*	*0.958*	*0.965*	*0.934*	*0.943*	*0.956*	*1.040*	*0.966*	*0.011*	*0.013*	*0.022*	*0.043*	*0.055*	*0.020*	*0.111*	*0.039*
	4	Y	0.974	0.970	0.973	0.959	0.968	0.966	0.971	0.969	0.012	0.009	0.010	0.010	0.011	0.017	0.009	0.011
	5	Y	0.980	0.965	0.973	0.960	0.977	0.974	0.964	0.970	0.022	0.005	0.005	0.005	0.006	0.010	0.014	0.010
9	*0*	*N*	*0.979*	*0.979*	*0.977*	*0.982*	*0.973*	*0.969*	*0.992*	*0.979*	*0.017*	*0.010*	*0.011*	*0.010*	*0.010*	*0.009*	*0.023*	*0.013*
	1	*N*	*0.983*	*0.982*	*0.986*	*0.990*	*0.983*	*0.975*	*0.995*	*0.985*	*0.013*	*0.012*	*0.007*	*0.010*	*0.012*	*0.009*	*0.018*	*0.012*
	2	Y	0.974	0.984	0.987	0.988	0.984	0.968	0.978	0.980	0.013	0.010	0.009	0.005	0.007	0.008	0.012	0.009
	3	Y	0.989	0.990	0.996	0.994	0.982	0.973	0.988	0.987	0.014	0.012	0.009	0.011	0.011	0.006	0.029	0.013

DPT ID	Lap	Lap Used	Field Calibration Factor								Standard Deviation of Deviation Ratio (SDDR, µm)							
			D1	D2	D3	D4	D5	D6	D7	mean	D1	D2	D3	D4	D5	D6	D7	mean
10	*0*	*N*	*0.982*	*0.997*	*0.998*	*1.000*	*1.005*	*1.025*	*1.018*	*1.004*	*0.016*	*0.008*	*0.011*	*0.014*	*0.015*	*0.021*	*0.028*	*0.016*
	1	*N*	*0.993*	*1.000*	*0.995*	*0.990*	*1.004*	*1.018*	*1.015*	*1.002*	*0.010*	*0.007*	*0.008*	*0.010*	*0.013*	*0.015*	*0.032*	*0.013*
	2	Y	0.989	0.998	0.994	0.989	0.996	1.018	1.000	0.998	0.010	0.012	0.010	0.014	0.014	0.013	0.025	0.014
	3	Y	0.993	1.001	1.003	1.001	1.005	1.016	1.019	1.005	0.015	0.007	0.008	0.010	0.007	0.014	0.024	0.012
	4	*N*	*1.007*	*1.010*	*1.015*	*1.003*	*1.012*	*1.028*	*1.031*	*1.015*	*0.009*	*0.011*	*0.012*	*0.007*	*0.014*	*0.018*	*0.017*	*0.013*
	5	*N*	*1.005*	*1.008*	*1.013*	*1.006*	*1.016*	*1.036*	*1.023*	*1.015*	*0.013*	*0.008*	*0.005*	*0.009*	*0.009*	*0.021*	*0.017*	*0.012*
11	*0*	*N*	*0.975*	*0.963*	*0.964*	*0.981*	*0.969*	*0.967*	*0.986*	*0.972*	*0.016*	*0.012*	*0.017*	*0.021*	*0.024*	*0.028*	*0.050*	*0.024*
	1	*N*	*0.973*	*0.965*	*0.962*	*0.974*	*0.970*	*0.965*	*0.976*	*0.969*	*0.015*	*0.011*	*0.014*	*0.015*	*0.017*	*0.023*	*0.037*	*0.019*
	2	Y	0.978	0.965	0.965	0.977	0.969	0.964	0.973	0.970	0.013	0.013	0.015	0.019	0.020	0.026	0.044	0.021
	3	Y	0.976	0.964	0.968	0.984	0.974	0.965	0.981	0.973	0.008	0.009	0.012	0.015	0.017	0.021	0.040	0.017
13	*0*	*N*	*0.979*	*0.979*	*0.973*	*0.985*	*0.973*	*0.986*	*0.981*	*0.979*	*0.020*	*0.010*	*0.010*	*0.009*	*0.014*	*0.009*	*0.031*	*0.015*
	1	*N*	*0.972*	*0.976*	*0.972*	*0.980*	*0.972*	*0.985*	*0.975*	*0.976*	*0.010*	*0.014*	*0.017*	*0.016*	*0.021*	*0.018*	*0.017*	*0.016*
	2	Y	0.973	0.978	0.974	0.979	0.973	0.982	0.979	0.977	0.011	0.008	0.011	0.012	0.013	0.018	0.033	0.015
	3	Y	0.981	0.981	0.979	0.984	0.975	0.982	0.978	0.980	0.007	0.005	0.009	0.008	0.010	0.012	0.030	0.012
	4	*N*	*0.999*	*0.989*	*0.990*	*0.994*	*0.985*	*1.003*	*0.994*	*0.993*	*0.012*	*0.007*	*0.008*	*0.008*	*0.010*	*0.013*	*0.033*	*0.013*
	5	*N*	*0.995*	*0.986*	*0.988*	*0.992*	*0.988*	*1.000*	*0.992*	*0.992*	*0.018*	*0.007*	*0.009*	*0.009*	*0.009*	*0.011*	*0.025*	*0.013*
15	*0*	*N*	*1.022*	*1.013*	*1.047*	*1.018*	*1.009*	*1.026*	*1.020*	*1.022*	*0.014*	*0.008*	*0.008*	*0.008*	*0.009*	*0.009*	*0.010*	*0.009*
	1	*N*	*1.018*	*1.010*	*1.640*	*1.012*	*1.009*	*1.021*	*1.020*	*1.104*	*0.009*	*0.006*	*0.244*	*0.007*	*0.008*	*0.009*	*0.013*	*0.042*
	2	Y	1.023	1.015	1.015	1.016	1.013	1.025	1.023	1.019	0.016	0.005	0.006	0.004	0.007	0.009	0.009	0.008
	3	Y	1.020	1.013	1.013	1.019	1.011	1.022	1.018	1.016	0.016	0.007	0.007	0.007	0.007	0.007	0.009	0.009
16	*0*	*N*	*1.016*	*1.021*	*1.018*	*1.021*	*1.016*	*1.025*	*0.975*	*1.013*	*0.012*	*0.007*	*0.006*	*0.008*	*0.008*	*0.010*	*0.016*	*0.010*
	1	*N*	*1.021*	*1.020*	*1.017*	*1.017*	*1.017*	*1.024*	*0.973*	*1.013*	*0.011*	*0.007*	*0.007*	*0.008*	*0.010*	*0.009*	*0.018*	*0.010*
	2	Y	1.022	1.023	1.024	1.021	1.016	1.026	0.971	1.015	0.007	0.005	0.007	0.010	0.014	0.011	0.019	0.011
	3	Y	1.022	1.023	1.024	1.023	1.021	1.027	0.969	1.016	0.008	0.009	0.010	0.009	0.013	0.013	0.026	0.013

DPT ID	Lap	Lap Used	Field Calibration Factor								Standard Deviation of Deviation Ratio (SDDR, µm)							
			D1	D2	D3	D4	D5	D6	D7	mean	D1	D2	D3	D4	D5	D6	D7	mean
28	*0*	*N*	*1.036*	*1.019*	*1.015*	*1.029*	*1.027*	*0.998*	*1.022*	*1.021*	*0.018*	*0.014*	*0.011*	*0.014*	*0.012*	*0.016*	*0.024*	*0.016*
	1	*N*	*1.037*	*1.026*	*1.011*	*1.031*	*1.035*	*1.018*	*1.024*	*1.026*	*0.012*	*0.009*	*0.012*	*0.016*	*0.010*	*0.015*	*0.021*	*0.013*
	2	Y	1.040	1.030	1.020	1.034	1.036	1.023	1.017	1.029	0.016	0.015	0.010	0.014	0.012	0.018	0.024	0.016
	3	Y	1.044	1.026	1.024	1.037	1.038	1.023	1.026	1.031	0.017	0.017	0.015	0.014	0.015	0.018	0.023	0.017
	4	*N*	*1.061*	*1.041*	*1.039*	*1.043*	*1.045*	*1.031*	*1.046*	*1.044*	*0.018*	*0.013*	*0.018*	*0.016*	*0.018*	*0.022*	*0.036*	*0.020*
	5	*N*	*1.056*	*1.037*	*1.036*	*1.043*	*1.042*	*1.041*	*1.026*	*1.040*	*0.016*	*0.010*	*0.016*	*0.019*	*0.015*	*0.022*	*0.034*	*0.019*
30	*0*	*N*	*0.947*	*0.972*	*0.956*	*0.964*	*0.959*	*0.961*	*0.957*	*0.959*	*0.023*	*0.008*	*0.008*	*0.008*	*0.015*	*0.009*	*0.023*	*0.014*
	1	*N*	*0.933*	*0.971*	*0.952*	*0.955*	*0.964*	*0.955*	*0.954*	*0.955*	*0.027*	*0.008*	*0.019*	*0.011*	*0.015*	*0.016*	*0.025*	*0.017*
	2	Y	0.947	0.970	0.958	0.963	0.968	0.958	0.955	0.960	0.017	0.014	0.012	0.009	0.017	0.015	0.042	0.018
	3	Y	0.952	0.977	0.963	0.964	0.967	0.952	0.949	0.961	0.015	0.012	0.010	0.009	0.018	0.014	0.028	0.015
	4	*N*	*0.966*	*0.981*	*0.978*	*0.977*	*0.984*	*0.973*	*0.982*	*0.977*	*0.018*	*0.015*	*0.012*	*0.009*	*0.011*	*0.008*	*0.024*	*0.014*
	5	*N*	*0.970*	*0.980*	*0.974*	*0.970*	*0.973*	*0.972*	*0.960*	*0.971*	*0.023*	*0.018*	*0.011*	*0.018*	*0.015*	*0.015*	*0.016*	*0.016*
32	*0*	*N*	*1.027*	*1.033*	*1.030*	*1.041*	*1.045*	*1.018*	*0.994*	*1.027*	*0.019*	*0.016*	*0.017*	*0.024*	*0.024*	*0.041*	*0.056*	*0.028*
	1	*N*	*1.030*	*1.030*	*1.022*	*1.029*	*1.050*	*1.005*	*0.996*	*1.023*	*0.011*	*0.013*	*0.014*	*0.019*	*0.022*	*0.036*	*0.045*	*0.023*
	2	Y	1.030	1.038	1.039	1.039	1.050	1.006	0.988	1.027	0.019	0.017	0.024	0.024	0.029	0.042	0.063	0.031
	3	Y	1.037	1.032	1.030	1.033	1.046	0.999	0.981	1.023	0.014	0.012	0.013	0.020	0.026	0.033	0.055	0.025
33	*0*	*N*	*1.027*	*1.033*	*1.031*	*1.033*	*1.026*	*1.053*	*1.007*	*1.030*	*0.018*	*0.010*	*0.013*	*0.012*	*0.020*	*0.023*	*0.054*	*0.021*
	1	*N*	*1.033*	*1.036*	*1.034*	*1.033*	*1.032*	*1.051*	*1.007*	*1.032*	*0.015*	*0.014*	*0.019*	*0.016*	*0.023*	*0.024*	*0.060*	*0.024*
	2	Y	1.030	1.032	1.035	1.033	1.027	1.055	0.996	1.030	0.017	0.013	0.014	0.017	0.024	0.025	0.049	0.023
	3	Y	1.036	1.035	1.037	1.035	1.026	1.049	0.992	1.030	0.011	0.011	0.012	0.011	0.018	0.018	0.057	0.020
34	*0*	*N*	*1.056*	*1.024*	*1.019*	*1.018*	*1.033*	*1.035*	*1.053*	*1.034*	*0.025*	*0.007*	*0.007*	*0.009*	*0.011*	*0.018*	*0.020*	*0.014*
	1	*N*	*1.049*	*1.021*	*1.018*	*1.015*	*1.031*	*1.027*	*1.044*	*1.029*	*0.035*	*0.008*	*0.009*	*0.010*	*0.012*	*0.016*	*0.038*	*0.018*
	2	Y	1.050	1.020	1.016	1.014	1.030	1.022	1.024	1.025	0.018	0.006	0.005	0.010	0.008	0.018	0.033	0.014
	3	Y	1.049	1.024	1.021	1.020	1.027	1.021	1.046	1.030	0.043	0.013	0.012	0.016	0.011	0.019	0.036	0.022
36	*0*	*N*	*1.028*	*1.086*	*1.081*	*1.080*	*1.094*	*1.091*	*1.085*	*1.078*	*0.044*	*0.013*	*0.011*	*0.015*	*0.018*	*0.023*	*0.038*	*0.023*
	1	*N*	*1.029*	*1.086*	*1.081*	*1.075*	*1.095*	*1.087*	*1.087*	*1.077*	*0.050*	*0.011*	*0.010*	*0.014*	*0.017*	*0.024*	*0.035*	*0.023*
	2	Y	0.956	0.997	0.994	0.989	1.001	0.996	0.992	0.989	0.035	0.012	0.011	0.019	0.018	0.030	0.044	0.024
	3	Y	0.961	1.000	0.996	0.992	1.002	0.996	0.998	0.992	0.026	0.015	0.015	0.020	0.025	0.032	0.055	0.027

DPT ID	Lap	Lap Used	Field Calibration Factor								Standard Deviation of Deviation Ratio (SDDR, µm)							
			D1	D2	D3	D4	D5	D6	D7	mean	D1	D2	D3	D4	D5	D6	D7	mean
37	*0*	*N*	*1.044*	*1.040*	*1.028*	*1.043*	*1.023*	*1.030*	*1.016*	*1.032*	*0.013*	*0.019*	*0.020*	*0.020*	*0.026*	*0.037*	*0.054*	*0.027*
	1	*N*	*1.046*	*1.038*	*1.027*	*1.039*	*1.029*	*1.031*	*1.020*	*1.033*	*0.018*	*0.020*	*0.022*	*0.021*	*0.023*	*0.036*	*0.050*	*0.027*
	2	Y	1.058	1.047	1.038	1.050	1.037	1.039	1.022	1.042	0.019	0.024	0.024	0.024	0.029	0.035	0.063	0.031
	3	Y	1.054	1.047	1.038	1.049	1.035	1.033	1.021	1.040	0.019	0.022	0.020	0.020	0.024	0.035	0.054	0.028
38	*0*	*N*	*0.975*	*0.967*	*0.953*	*0.943*	*0.956*	*0.930*	*1.014*	*0.963*	*0.020*	*0.014*	*0.012*	*0.020*	*0.014*	*0.021*	*0.042*	*0.020*
	1	*N*	*0.969*	*0.960*	*0.948*	*0.935*	*0.945*	*0.919*	*1.010*	*0.955*	*0.017*	*0.015*	*0.012*	*0.019*	*0.014*	*0.028*	*0.041*	*0.021*
	2	Y	0.976	0.969	0.960	0.945	0.952	0.926	1.008	0.962	0.015	0.013	0.011	0.019	0.011	0.024	0.039	0.019
	3	Y	0.969	0.961	0.954	0.938	0.943	0.917	1.005	0.955	0.013	0.010	0.005	0.014	0.009	0.023	0.032	0.015
39	*0*	*N*	*0.972*	*0.989*	*0.980*	*0.993*	*0.985*	*0.997*	*0.994*	*0.987*	*0.017*	*0.009*	*0.007*	*0.005*	*0.005*	*0.007*	*0.019*	*0.010*
	1	*N*	*0.978*	*0.992*	*0.983*	*0.994*	*0.992*	*0.995*	*0.997*	*0.990*	*0.015*	*0.011*	*0.009*	*0.007*	*0.008*	*0.011*	*0.019*	*0.011*
	2	Y	0.979	0.989	0.985	0.994	0.986	0.997	0.979	0.987	0.015	0.008	0.008	0.006	0.009	0.010	0.014	0.010
	3	Y	0.982	0.994	0.987	0.998	0.986	0.998	0.985	0.990	0.012	0.005	0.005	0.006	0.007	0.011	0.023	0.010
	4	*N*	*0.993*	*1.002*	*0.998*	*0.999*	*0.995*	*1.003*	*0.999*	*0.998*	*0.015*	*0.006*	*0.007*	*0.006*	*0.007*	*0.010*	*0.016*	*0.010*
	5	*N*	*1.001*	*1.007*	*1.004*	*1.008*	*1.005*	*1.011*	*0.999*	*1.005*	*0.016*	*0.008*	*0.009*	*0.008*	*0.006*	*0.009*	*0.012*	*0.010*
40	*0*	*N*	*1.021*	*1.018*	*1.014*	*1.019*	*1.025*	*1.035*	*1.046*	*1.025*	*0.009*	*0.006*	*0.009*	*0.012*	*0.013*	*0.014*	*0.027*	*0.013*
	1	*N*	*1.027*	*1.018*	*1.013*	*1.020*	*1.026*	*1.040*	*1.052*	*1.028*	*0.018*	*0.008*	*0.011*	*0.012*	*0.012*	*0.022*	*0.024*	*0.015*
	2	Y	1.025	1.022	1.021	1.027	1.032	1.040	1.050	1.031	0.017	0.005	0.005	0.009	0.010	0.014	0.024	0.012
	3	Y	1.028	1.026	1.027	1.032	1.028	1.044	1.052	1.034	0.015	0.004	0.006	0.006	0.008	0.015	0.021	0.011
41	*0*	*N*	*1.002*	*0.996*	*1.001*	*1.000*	*1.002*	*1.009*	*0.990*	*1.000*	*0.013*	*0.009*	*0.009*	*0.011*	*0.008*	*0.013*	*0.033*	*0.014*
	1	*N*	*1.005*	*1.001*	*1.006*	*0.999*	*1.008*	*1.008*	*1.001*	*1.004*	*0.013*	*0.010*	*0.008*	*0.010*	*0.011*	*0.012*	*0.027*	*0.013*
	2	Y	1.005	0.993	1.004	0.994	1.000	1.012	1.007	1.002	0.008	0.007	0.010	0.010	0.015	0.023	0.040	0.016
	3	Y	1.006	0.996	1.007	0.998	1.003	1.010	0.999	1.003	0.010	0.007	0.010	0.008	0.013	0.013	0.034	0.013
42	*0*	*N*	*0.973*	*0.975*	*0.969*	*0.979*	*0.977*	*0.978*	*0.967*	*0.974*	*0.010*	*0.005*	*0.010*	*0.010*	*0.008*	*0.012*	*0.023*	*0.011*
	1	*N*	*0.974*	*0.976*	*0.970*	*0.979*	*0.979*	*0.979*	*0.984*	*0.977*	*0.012*	*0.007*	*0.008*	*0.009*	*0.010*	*0.011*	*0.026*	*0.012*
	2	Y	0.981	0.986	0.986	0.997	0.990	0.992	0.991	0.989	0.026	0.010	0.010	0.012	0.014	0.014	0.020	0.015
	3	Y	0.980	0.980	0.978	0.986	0.982	0.981	0.989	0.982	0.011	0.005	0.007	0.009	0.009	0.012	0.021	0.011

Table F.2 2014 Final trial data (analysed laps with selected geophones removed where appropriate)

DPT ID	Lap	Field Calibration Factor								Standard Deviation of Deviation Ratio (SDDR, µm)								Excluded Geophones and Test Station
		D1	D2	D3	D4	D5	D6	D7	mean	D1	D2	D3	D4	D5	D6	D7	mean	
5	2	0.996	0.999	0.992	1.001	0.997	1.008	1.011	1.001	0.010	0.008	0.010	0.009	0.012	0.020	0.030	0.014	
	3	0.992	0.991	0.986	0.995	0.986	0.990	1.008	0.993	0.007	0.007	0.009	0.011	0.014	0.015	0.039	0.015	
6	6	1.007	1.021	1.027	1.032	1.018	1.008	1.001	1.016	0.018	0.007	0.010	0.016	0.021	0.024	0.041	0.020	
	7	1.011	1.021	1.025	1.025	1.020	1.031	1.039	1.025	0.018	0.010	0.008	0.016	0.020	0.046	0.090	0.030	
8	4	0.974	0.970	0.973	0.959	0.968	0.966	0.971	0.969	0.012	0.009	0.010	0.010	0.011	0.017	0.009	0.011	
	5	0.980	0.965	0.973	0.960	0.977	0.974	0.964	0.970	0.022	0.005	0.005	0.005	0.006	0.010	0.014	0.010	
9	2	0.974	0.984	0.987	0.988	0.984	0.968	0.978	0.980	0.013	0.010	0.009	0.005	0.007	0.008	0.012	0.009	
	3	0.989	0.990	0.996	0.994	0.982	0.973	0.988	0.987	0.014	0.012	0.009	0.011	0.011	0.006	0.029	0.013	
10	2	0.989	0.998	0.994	0.989	0.996	1.018	1.000	0.998	0.010	0.012	0.010	0.014	0.014	0.013	0.025	0.014	
	3	0.993	1.001	1.003	1.001	1.005	1.016	1.019	1.005	0.015	0.007	0.008	0.010	0.007	0.014	0.024	0.012	
11	2	0.978	0.965	0.965	0.977	0.969	0.964	0.973	0.970	0.013	0.013	0.015	0.019	0.020	0.026	0.044	0.021	
	3	0.976	0.964	0.968	0.984	0.974	0.965	0.981	0.973	0.008	0.009	0.012	0.015	0.017	0.021	0.040	0.017	
13	2	0.973	0.978	0.974	0.979	0.973	0.982	0.979	0.977	0.011	0.008	0.011	0.012	0.013	0.018	0.033	0.015	
	3	0.981	0.981	0.979	0.984	0.975	0.982	0.978	0.980	0.007	0.005	0.009	0.008	0.010	0.012	0.030	0.012	
15	2	1.023	1.015	1.015	1.016	1.013	1.025	1.023	1.019	0.016	0.005	0.006	0.004	0.007	0.009	0.009	0.008	
	3	1.020	1.013	1.013	1.019	1.011	1.022	1.018	1.016	0.016	0.007	0.007	0.007	0.007	0.007	0.009	0.009	
16	2	1.022	1.023	1.024	1.021	1.016	1.026	0.971	1.015	0.007	0.005	0.007	0.010	0.014	0.011	0.019	0.011	
	3	1.022	1.023	1.024	1.023	1.021	1.027	0.969	1.016	0.008	0.009	0.010	0.009	0.013	0.013	0.026	0.013	
28	2	1.040	1.030	1.020	1.034	1.036	1.023	1.017	1.029	0.016	0.015	0.010	0.014	0.012	0.018	0.024	0.016	
	3	1.044	1.026	1.024	1.037	1.038	1.023	1.026	1.031	0.017	0.017	0.015	0.014	0.015	0.018	0.023	0.017	
30	2	0.947	0.970	0.958	0.963	0.968	0.958	0.955	0.960	0.017	0.014	0.012	0.009	0.017	0.015	0.042	0.018	
	3	0.952	0.977	0.963	0.964	0.967	0.952	0.949	0.961	0.015	0.012	0.010	0.009	0.018	0.014	0.028	0.015	
32	2	1.030	1.038	1.039	1.039	1.050	1.006	0.988	1.027	0.019	0.017	0.024	0.024	0.029	0.042	0.063	0.031	
	3	1.037	1.032	1.030	1.033	1.046	0.999	0.981	1.023	0.014	0.012	0.013	0.020	0.026	0.033	0.055	0.025	
33	2	1.030	1.032	1.035	1.033	1.027	1.055	0.996	1.030	0.017	0.013	0.014	0.017	0.024	0.025	0.049	0.023	
	3	1.036	1.035	1.037	1.035	1.026	1.049	0.992	1.030	0.011	0.011	0.012	0.011	0.018	0.018	0.057	0.020	

DPT ID	Lap	Field Calibration Factor								Standard Deviation of Deviation Ratio (SDDR, µm)								Excluded Geophones and Test Station
		D1	D2	D3	D4	D5	D6	D7	mean	D1	D2	D3	D4	D5	D6	D7	mean	
34	2	1.050	1.020	1.016	1.014	1.030	1.022	1.024	1.025	0.018	0.006	0.005	0.010	0.008	0.018	0.033	0.014	
	3	1.049	1.024	1.021	1.020	1.027	1.021	1.046	1.030	0.043	0.013	0.012	0.016	0.011	0.019	0.036	0.022	
36	2	0.956	0.997	0.994	0.989	1.001	0.996	0.992	0.989	0.035	0.012	0.011	0.019	0.018	0.030	0.044	0.024	
	3	0.961	1.000	0.996	0.992	1.002	0.996	0.998	0.992	0.026	0.015	0.015	0.020	0.025	0.032	0.055	0.027	
37	2	1.058	1.047	1.038	1.050	1.037	1.039	1.022	1.042	0.019	0.024	0.024	0.024	0.029	0.035	0.063	0.031	
	3	1.054	1.047	1.038	1.049	1.035	1.033	1.021	1.040	0.019	0.022	0.020	0.020	0.024	0.035	0.054	0.028	
38	2	0.976	0.969	0.960	0.945	0.952	0.926	1.008	0.962	0.015	0.013	0.011	0.019	0.011	0.024	0.039	0.019	
	3	0.969	0.961	0.954	0.938	0.943	0.917	1.005	0.955	0.013	0.010	0.005	0.014	0.009	0.023	0.032	0.015	
39	2	0.979	0.989	0.985	0.994	0.986	0.997	0.979	0.987	0.015	0.008	0.008	0.006	0.009	0.010	0.014	0.010	
	3	0.982	0.994	0.987	0.998	0.986	0.998	0.985	0.990	0.012	0.005	0.005	0.006	0.007	0.011	0.023	0.010	
40	2	1.025	1.022	1.021	1.027	1.032	1.040	1.050	1.031	0.017	0.005	0.005	0.009	0.010	0.014	0.024	0.012	
	3	1.028	1.026	1.027	1.032	1.028	1.044	1.052	1.034	0.015	0.004	0.006	0.006	0.008	0.015	0.021	0.011	
41	2	1.005	0.993	1.004	0.994	1.000	1.012	1.007	1.002	0.008	0.007	0.010	0.010	0.015	0.023	0.040	0.016	
	3	1.006	0.996	1.007	0.998	1.003	1.010	0.999	1.003	0.010	0.007	0.010	0.008	0.013	0.013	0.034	0.013	
42	2	0.981	0.986	0.986	0.997	0.990	0.992	0.991	0.989	0.026	0.010	0.010	0.012	0.014	0.014	0.020	0.015	
	3	0.980	0.980	0.978	0.986	0.982	0.981	0.989	0.982	0.011	0.005	0.007	0.009	0.009	0.012	0.021	0.011	

Appendix G Accreditation trial – Trial results

Table G.1 Performance rating for mandatory and non-mandatory tests

TRL Ref. no.	Make, model and serial number	Reproducibility				Elapsed distance	Repeatability			Temperature measurement	OSGR reproducibility (Horizontal)
		FCF		SDDR			Target load		SD of deflections		
		Mean	Individual	Mean	Individual		Mean	SD			
5	Dynatest HWD 8082 SN 050	Pass	Pass	Pass	Pass	Pass	High	High	High	Medium	No data
6	Dynatest HWD 8082 SN 018	Pass	Pass	Pass	Pass[1]	Pass	High	High	High	High	No data
8	Dynatest FWD 8002 SN 028	Pass	Pass	Pass	Pass	Pass	High	High	High	Low	No data
9	Dynatest 8002 FWD SN 136	Pass	Pass	Pass	Pass	Pass	High	High	High	High	High
10	Dynatest FWD 8002 SN 192	Pass	Pass	Pass	Pass	Pass	High	High	High	Low	No data
11	Dynatest FWD 8002 SN 187	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data
13	Dynatest HWD 8082 SN 029	Pass	Pass	Pass	Pass	Pass	High	High	High	Very Low	No data
15	Dynatest FWD 8002 SN 203	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data
16	Dynatest FWD 8002 SN 214	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data
28	Dynatest FWD 8002 SN 271	Pass	Pass	Pass	Pass	Pass	High	High	High	Very Low	No data
30	Dynatest 8002 FWD SN 173	Pass	Pass	Pass	Pass	Pass	High	High	Medium	High	High
32	Dynatest HWD 8082 SN 069	Pass	Pass	Pass	Pass	Pass	High	High	High	High	Invalid data
33	Dynatest HWD 8082 SN 070	Pass	Pass	Pass	Pass	Pass	High	High	High	High	Invalid data
34	Dynatest HWD 8082 SN 108	Pass	Pass	Pass	Pass	Pass	High	High	Medium	Low	No data
36	Grontmij FWD PRI2500 SN 0608¬-303	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data
37	Dynatest FWD 8002 SN 352	Pass	Pass	Pass	Pass	Pass	Medium	High	High	High	No data
38	Grontmij FWD PRI1500 SN 1111-448	Pass	Pass	Pass	Pass	Pass	High	High	High	High	Low
39	Dynatest FWD 8002 SN 388	Pass	Pass	Pass	Pass	Pass	High	High	High	High	High[2]
40	Dynatest FWD 8012 SN 002	Pass	Pass	Pass	Pass	Pass	High	High	High	High	High
41	Dynatest HWD 8082 SN 145	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data
42	Dynatest HWD 8082 SN 149	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data

[1] This machine achieved a pass for SDDR following additional testing after the trial.

[2] This machine achieved a High performance for OSGR following additional testing after the trial

Appendix H 2014 DPT trial – Contact details and summary outcome

Table H.1 2014 trial contact details and summary outcome

TRL Ref. no.	Owning Company	Make, model and serial number	Contact details	Recommend for use on HA network
5	URS Ltd.	Dynatest HWD 8082 SN 050	John Dobrzycki, URS, 12 Regan Way, Chetwynd Business Park, Chilwell, Nottingham NG9 6RZ	Yes
6	PMS Ltd.	Dynatest HWD 8082 SN 018	Eoin Greaney, PMS Pavement Management Services Ltd, Raheen Industrial Estate, Athenry, Co. Galway, Ireland	Yes
8	URS Ltd.	Dynatest FWD 8002 SN 028	As Machine 5	Yes
9	PMS Ltd.	Dynatest 8002 FWD SN 136	As Machine 6	Yes
10	URS Ltd.	Dynatest FWD 8002 SN 192	As Machine 5	Yes
11	Forth Bridge constructors JV	Dynatest FWD 8002 SN 187	Sandy Will. Forth Replacement Crossing Project Office, King Malcolm Drive, Rosyth, Fife, KY11 2DY	Yes
13	URS Ltd.	Dynatest HWD 8082 SN 029	As Machine 5	Yes
15	CET Infrastructure	Dynatest FWD 8002 SN 203	Thom Myers, CET Infrastructure Ltd, Highway House, 6 Lutterworth Road, Wolvey, Nr Hinckley, Leicestershire, LE10 3HW	Yes
16	PTS	Dynatest FWD 8002 SN 214	Tony Sewell, PTS Ltd, Unit 7, Canalside, Cowling Business Park, Chorley, PR6 0QL	Yes
28	Pulse Surveying Ltd.	Dynatest FWD 8002 SN 271	James Nash. Unit 17 Robinsons Industrial Estate, Shaftesbury Street, Derby, DE23 8NL	Yes
30	PMS Ltd.	Dynatest 8002 FWD SN 173	As Machine 6	Yes
32	ALC (MoD)	Dynatest HWD 8082 SN 069	Alan Robinson, ALC, ALC Regional Office, MoD Stafford, Building 102, 7 site, Beaconside, Stafford, ST18 0AQ	Yes
33	ALC (MoD)	Dynatest HWD 8082 SN 070	As Machine 32	Yes
34	PTS	Dynatest HWD 8082 SN 108	As Machine 16	Yes
36	TestConsult Ltd.	Grontmij FWD PRI2500 SN 0608¬-303	Mark Dawkins, Testconsult Limited, Ruby House, 40A Hardwick Grange, Woolston, Warrington, WA1 4RF	Yes
37	Stanger Testing	Dynatest FWD 8002 SN 352	Stanger Testing Services Ltd. Cambuslang Laboratory, Bogleshole Road, Cambuslang, Glasgow, G72 7DD	Yes
38	Milestone Pavement Technologies	Grontmij FWD PRI1500 SN 1111-448	Seamus O'Reilly. Unit 2A, Kells Enterprise and Technology Centre. Cavan Road, Kells, County Meath, Ireland	Yes
39	TRL	Dynatest FWD 8002 SN 388	Peter Langdale. TRL, Crowthorne House, Nine Mile Ride, Wokingham, Berkshire, RG40 3GA	Yes
40	Dynatest UK Ltd	Dynatest FWD 8012 SN 002	Tess Small, Dynatest UK Ltd, Service & Support, Unit 12, Acorn Enterprise Centre, Hoo Farm Industrial Estate, Frederick Road, Kidderminster, Worcestershire. DY11 7RA, UK	Yes
41	ALC (MoD)	Dynatest HWD 8082 SN 145	As Machine 32	Yes
42	ALC (MoD)	Dynatest HWD 8082 SN 149	As Machine 32	Yes

Appendix I Additional testing for Machine 6

During the 2014 DPT accreditation trial it was found that Machine 6 did not meet the mandatory criteria for SDDR (see section 3.2). The SDDR criteria are used to assess the consistency with which the machine tends to over- or under-read during a lap

Following the trial the machine was investigated to identify the fault with the machine. During the inspection it was found that the inner geophone holder springs were weak and distorted on several of the holders. It also appeared that the geophone 7 inner holder mounting base had not been cleaned correctly leaving a build-up of silicone grease (this grease is applied to the inner holder mounting bases to stop corrosion forming between the geophone magnet and the mounting base). This geophone is located under the spare wheel which may explain the build-up of grease. These issues were rectified, and the owner of this machine now believed that it would pass this assessment and therefore asked if it could be retested.

Typically, a retest would require holding a "mini-trial" where the machine seeking accreditation is tested alongside a selection of the fleet to provide a reference dataset to be assessed against. However, even though Machine produced poor results with regards to SDDR, it produced good results for FCF (assessment of average bias). Therefore within a short period of the trial this machine should on average, produce results consistent with the rest of the fleet. Bearing this in mind the following assessment procedure was developed:

1. The machine will conduct five reproducibility laps of the accreditation trial test site. The average of all five laps will be used as the reference and the SDDR criteria will be assessed on each lap against this reference.
2. Temperature data and/or data from another DPT device will be collected to provide assurance that the repairs undertaken have not caused the machine's measurements to deviate from those of the fleet.
3. If the machine passes the SDDR criteria on all five laps, and the deflection data is shown to be consistent with the fleet (either by direct comparison or from predicted deflection level).

Note: the above test procedure has been developed based on the performance of Machine 6 with regards to the other criteria at the November 2014 Accreditation trial. Machines which fail future trials may require additional and/or different testing (including in some cases the need for a mini trial) depending on the exact circumstances.

Machine 6 was retested according to the above procedure and was found to be producing acceptable data and has therefore been awarded a pass with regards to SDDR.

Highways Agency 2014 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 (FWDs and HWDs) supported by ongoing QA for the devices. In order to undertake accredited surveys, the survey devices are required to meet the mandatory criteria of the trial.

This report covers the 2014 trial run by TRL and held on the Horiba-MIRA proving ground between 11th and 12th November 2014.

Other titles from this subject area

CPR 1712 Highways Agency 2013 National Falling Weight Deflectometer Accreditation Trial. S Brittain. 2013

CPR 1533 Highways Agency 2012 National Falling Weight Deflectometer Accreditation Trial. S Brittain. 2012

CPR 1450 Highways Agency 2011 National Falling Weight Deflectometer Correlation Trials. S Brittain. 2011

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

ISSN 2514-9652

ISBN 978-1-913246-33-4

PPR947