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Highways England 2015 National Dynamic Plate Test device Accreditation Trial

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Executive Summary

The 2015 UK Dynamic Plate Test device (DPT) accreditation trial was held on the Twin Straights on the MIRA proving ground, on the 29th and 30th September 2015. This was the seventeenth mandatory DPT accreditation trial to be held in the UK with the objective being to assess the performance of all DPT devices likely to be operating on the Highways England (HE) 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 HE strategic road network.

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

- eleven trailer-mounted Dynatest FWDs,
- eight Dynatest trailer-mounted HWDs,
- one Grontmij trailer-mounted FWD,
- one Grontmij trailer-mounted HWD
- one PaveTesting trailer-mounted FWD

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 temperature measurement devices (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.

Eighteen machines met the mandatory reproducibility trial requirements for Field Calibration Factor (FCF), Standard Deviation of Deviation Ratio (SDDR) and elapsed distance.

Of the three remaining machines:

- One met the mean and individual requirements for FCF and SDDR but did not meet the elapsed distance criteria.
- One met the mean and individual requirements for FCF and the mean SDDR, but did not meet the individual SDDR and the elapsed distance criteria.
- One met the mean FCF criteria but did not meet the remaining mandatory criteria.

Twenty 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). The remaining two machines did not undergo this assessment due to their performance during the reproducibility testing.

Twenty-one machines achieved a high performance in the non-mandatory temperature measurement assessment. The remaining machine achieved a low performance rating.

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

In summary, eighteen machines of the twenty-two machines that participated in the 2015 DPT accreditation trial met the mandatory requirements of the HE's annual accreditation trial.

Although not formally assessed at the trial, data from the measurement of air and surface temperature sensors fitted to some of the machines was collected and investigated. It was found that the surface temperature measurements were quite variable, however the air temperature measurements were reasonably consistent.

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

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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 accreditation trial before being accredited for operating on the Highways England's (HE) 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" requires that FWDs be approved at an annual accreditation trial before they may be permitted to survey on MoD airfields.

As satisfactory performance at a accreditation trial is required for subsequent accreditation for use on the HE 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 2015 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 seventeenth mandatory UK DPT accreditation trial was held on 29th and 30th September 2015 on behalf of Highways England (HE). The trial followed the basic format that was used successfully in the previous mandatory trials carried out since 1999. The 2015 trial included the following mandatory checks:

- Reproducibility
- Distance measurement

And the following non-mandatory checks

- Repeatability
- Temperature measurement devices/probes calibration check
- 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 September 2015 accreditation trial and presents the details of the machines that took part in the trial.

2 Trial Format

2.1 Participants

Twenty-two machines (all trailer-mounted) took part in the 2015 HE DPT accreditation trial, comprising thirteen FWDs and nine HWDs. A total of thirteen 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	1× Dynatest 8012 FWD and 1 × Dynatest 8082 HWD
Forth Bridge Constructors JV	Dynatest 8002 FWD
Milestone Pavement Technologies	Grontmij Primax 1500 FWD
Pavetesting	1 × PaveTesting 074PT0715 FWD
PMS Ltd. (Eire)	2 × Dynatest 8002 FWD
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
AECOM	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 four main 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).

The operator's temperature probes were compared using a stabilised environment to provide a simple check on the calibration of these devices.

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) HE 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 22)
Completed Check list returned to TRL before trial	22
Provide evidence and date of last manufacturer's calibration	21
Provide evidence and date of last dynamic calibration.	16
Provide evidence and date of last tower calibration	16
Calibration details correct in field program	18
All seven geophones in correct positions	17
Correct seating of frame	21

During the machine inspections it was found that the design of the beam lifting mechanism on Machine 43 (a new device constructed by PaveTesting) meant that it was not possible to set all of the geophones to the required positions. As a result of this it will not be possible for this machine to meet the mandatory requirements of the trial. However as this device was a prototype device it continued to take part in the rest of the trial to determine if it would be likely to meet the mandatory requirements of future trials once the beam lifting mechanism had been altered.

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 were conducted on day 1 using stations 2, 5, 8 and 13 and the test criteria can be found in section 3.1. Two machines (Machine 15 and 33) provided data with loads outside of the required tolerance, and one machine (Machine 11) provided poor performance on one of the test stations. The crews of these machines were asked to inspect their machines (prior to the reproducibility tests on day 2) and repeated the repeatability assessment on day 2. Machine 32 was not available to conduct the Repeatability testing during day 1, and due to its poor performance in the Reproducibility tests it was deemed unnecessary to undertake the Repeatability assessment for this machine. Machine 43 took part in this test on day 1, and appeared to perform well in terms of repeatability. However, analysis of the data (and from the inspection of the check lap) found that this machine was producing values significantly lower than the other machines. This issue was resolved prior to the reproducibility testing on day 2, however the machine did not meet all of the deflection criteria and therefore this machine did not repeat the repeatability testing.

In the tables below, the data for Machines 11, 15 and 33 are from day 2 and the data for the other machines from day 1 (Machines 32 and 43 are excluded from the table).

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	705.5	0.5%	690.1	0.5%	692.7	0.4%	676.3	0.4%
8	714.2	0.2%	692.8	0.2%	710.6	0.3%	709.2	0.5%
9	684.3	0.3%	652.5	0.2%	673.9	0.4%	687.0	0.3%
10	691.4	0.3%	673.6	0.3%	682.3	0.3%	688.9	0.3%
11	730.9	0.3%	714.5	0.2%	721.1	0.2%	726.7	0.3%
13	712.0	0.2%	711.1	0.2%	702.7	0.6%	694.6	0.2%
15	663.3	0.3%	646.1	0.3%	657.6	0.3%	662.3	0.5%
16	772.2	0.5%	749.2	0.5%	762.9	0.6%	760.3	0.4%
28	657.6	0.2%	643.3	0.1%	651.5	0.3%	657.8	0.2%
30	677.0	0.2%	661.0	0.1%	665.7	0.2%	668.7	0.2%
33	717.3	0.2%	719.3	0.4%	700.0	0.6%	710.3	0.4%
34	723.2	0.4%	719.7	0.8%	714.6	0.6%	712.2	0.6%
36	726.4	1.1%	728.9	1.1%	719.5	1.3%	703.0	1.0%
37	735.8	0.2%	712.0	0.3%	724.9	0.4%	732.2	0.4%
38	707.4	0.5%	716.5	0.8%	715.7	0.6%	705.6	0.6%
39	713.9	0.2%	682.5	0.3%	695.3	0.3%	718.7	0.2%
40	704.0	0.1%	697.4	0.1%	699.1	0.0%	700.7	0.1%
41	723.5	0.4%	720.2	0.4%	718.2	0.3%	726.6	0.4%
42	723.0	0.1%	705.2	0.1%	718.8	0.1%	720.8	0.1%
44	670.2	0.4%	667.3	0.3%	667.3	0.4%	670.4	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 all of the assessed machines meet the High performance for the mean of the applied load and the standard deviation of the applied load.

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	0.25	0.19	0.14	0.14	0.10	0.08	0.06
	5	0.10	0.16	0.14	0.20	0.20	0.13	0.22
	8	0.18	0.16	0.13	0.23	0.11	0.15	0.25
	13	0.22	0.26	0.13	0.16	0.12	0.21	0.20
8	2	0.07	0.15	0.07	0.12	0.17	0.15	0.16
	5	0.11	0.10	0.11	0.11	0.07	0.06	0.08
	8	0.21	0.23	0.19	0.20	0.15	0.14	0.19
	13	0.29	0.28	0.27	0.24	0.24	0.15	0.10
9	2	0.16	0.08	0.10	0.10	0.12	0.12	0.10
	5	0.37	0.29	0.20	0.26	0.18	0.10	0.12
	8	0.20	0.52	0.20	0.08	0.11	0.08	0.20
	13	0.14	0.15	0.19	0.11	0.18	0.12	0.14
10	2	0.13	0.09	0.06	0.20	0.22	0.11	0.11
	5	0.18	0.16	0.10	0.11	0.26	0.14	0.56
	8	0.11	0.11	0.11	0.24	0.19	0.13	0.31
	13	0.09	0.17	0.05	0.09	0.04	0.18	0.21
11	2	0.13	0.10	0.12	0.12	0.15	0.11	0.18
	5	0.24	0.24	0.39	0.16	0.15	0.12	0.16
	8	0.20	0.18	0.17	0.17	0.18	0.20	0.16
	13	0.18	0.17	0.15	0.26	0.15	0.17	0.18
13	2	0.73	0.25	0.18	0.07	0.26	0.26	0.17
	5	0.14	0.12	0.16	0.19	0.16	0.12	0.27
	8	0.52	0.25	0.23	0.24	0.33	0.55	0.31
	13	0.44	0.08	0.29	0.32	0.23	0.50	0.32
15	2	0.09	0.13	0.07	0.05	0.07	0.07	0.10
	5	0.14	0.14	0.06	0.08	0.12	0.11	0.26
	8	0.18	0.21	0.11	0.17	0.32	0.25	0.48
	13	0.15	0.23	0.61	0.36	0.34	0.22	0.17
16	2	0.40	0.39	0.20	0.44	0.28	0.52	0.55
	5	0.54	0.64	0.64	0.62	0.31	0.75	0.71
	8	0.52	0.51	0.48	0.41	0.87	0.48	0.79
	13	0.72	0.45	0.21	0.54	0.69	0.48	0.29
28	2	0.06	0.86	0.41	0.43	0.15	0.15	0.08
	5	0.20	0.33	0.55	0.73	0.11	0.11	0.20
	8	0.23	0.24	0.22	0.38	0.21	0.21	0.18
	13	0.25	0.14	0.14	0.15	0.17	0.40	0.15
30	2	0.11	0.15	0.15	0.09	0.09	0.42	0.26
	5	0.29	0.27	0.25	0.26	0.18	0.32	0.35
	8	0.12	0.31	0.15	0.09	0.11	0.35	0.44
	13	0.14	0.23	0.14	0.10	0.28	0.49	0.57

Machine number	Station	Ratio of standard deviation of normalised deflections to the test criteria						
		D1	D2	D3	D4	D5	D6	D7
33	2	0.08	0.04	0.13	0.06	0.17	0.07	0.15
	5	0.22	0.33	0.21	0.35	0.14	0.20	0.48
	8	0.16	0.25	0.39	0.11	0.20	0.20	0.26
	13	0.23	0.15	0.14	0.26	0.30	0.34	0.50
34	2	0.13	0.15	0.10	0.13	0.06	0.11	0.11
	5	0.73	0.61	0.55	0.48	0.35	0.31	0.28
	8	0.49	0.46	0.44	0.37	0.27	0.20	0.12
	13	0.39	0.28	0.28	0.24	0.19	0.22	0.15
36	2	0.06	0.09	0.07	0.05	0.11	0.04	0.04
	5	0.12	0.13	0.13	0.12	0.12	0.08	0.10
	8	0.13	0.13	0.12	0.09	0.07	0.06	0.07
	13	0.07	0.06	0.07	0.07	0.03	0.04	0.04
37	2	0.09	0.18	0.05	0.21	0.12	0.18	0.05
	5	0.13	0.21	0.19	0.19	0.11	0.11	0.06
	8	0.12	0.20	0.33	0.08	0.13	0.13	0.17
	13	0.14	0.23	0.10	0.38	0.08	0.43	0.09
38	2	0.06	0.05	0.06	0.04	0.08	0.05	0.06
	5	0.14	0.10	0.12	0.11	0.12	0.11	0.08
	8	0.12	0.13	0.12	0.10	0.08	0.11	0.08
	13	0.07	0.10	0.06	0.05	0.07	0.08	0.03
39	2	0.23	0.24	0.48	0.35	0.16	0.21	0.43
	5	0.37	0.16	0.22	0.25	0.25	0.54	0.49
	8	0.49	0.31	0.43	0.38	0.28	0.47	0.34
	13	0.49	0.39	0.17	0.19	0.24	0.23	0.48
40	2	0.13	0.06	0.08	0.15	0.06	0.08	0.11
	5	0.20	0.10	0.13	0.13	0.25	0.14	0.23
	8	0.21	0.07	0.09	0.09	0.11	0.06	0.07
	13	0.23	0.09	0.10	0.11	0.10	0.11	0.08
41	2	0.13	0.11	0.24	0.15	0.07	0.28	0.14
	5	0.38	0.42	0.37	0.38	0.24	0.50	0.25
	8	0.30	0.23	0.25	0.34	0.18	0.30	0.17
	13	0.31	0.29	0.44	0.16	0.27	0.11	0.25
42	2	0.04	0.14	0.25	0.03	0.02	0.02	0.28
	5	0.16	0.15	0.32	0.24	0.32	0.35	0.02
	8	0.36	0.11	0.14	0.14	0.24	0.21	0.17
	13	0.30	0.06	0.22	0.26	0.35	0.33	0.02
44	2	0.16	0.23	0.12	0.40	0.28	0.07	0.17
	5	0.35	0.30	0.29	0.58	0.21	0.34	0.32
	8	0.27	0.20	0.34	0.45	0.20	0.29	0.25
	13	0.28	0.42	0.34	0.40	0.27	0.41	0.31

On examination of the data it can be seen that all of the assessed machines meet the High performance for standard deviation of normalised deflections. In addition 71% 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 computer for Machine 11 failed during this testing and failed to save the data for the run and Machine 32 was not available to take part.

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.

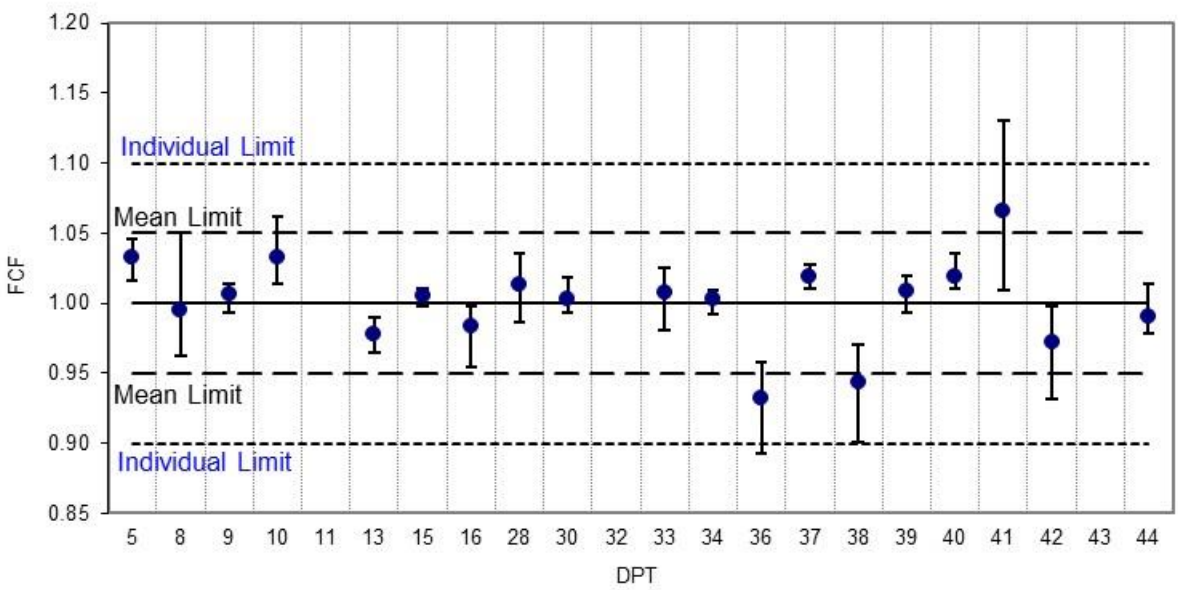

Figure 4.1 Field calibration factors (FCF) (check lap, no data removed)

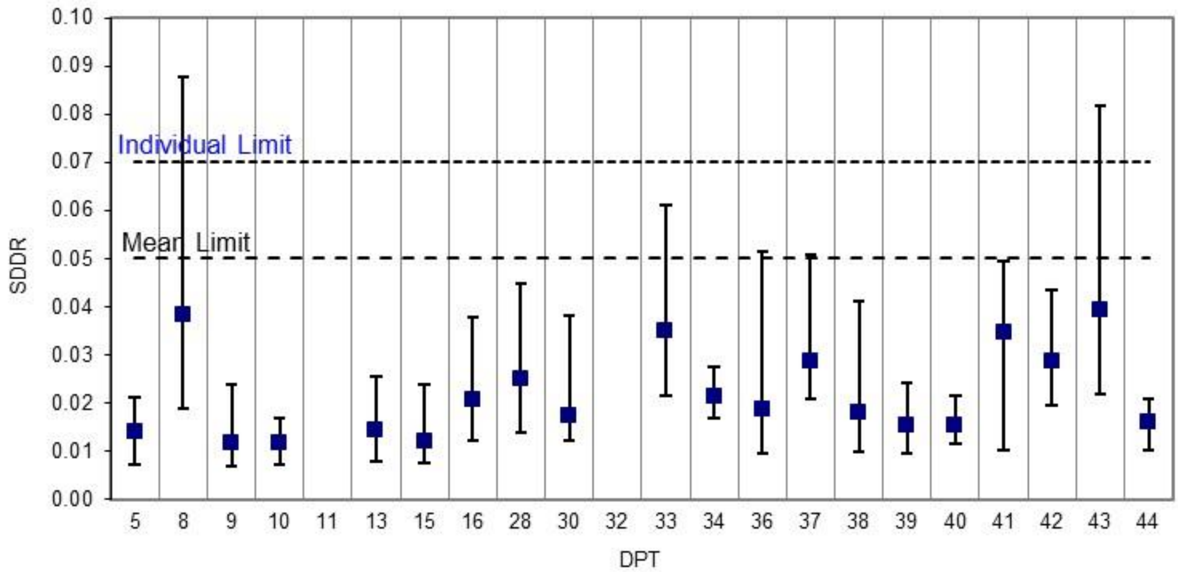

Figure 4.2 Standard deviation of the deviation ratio (SDDR) (check lap, no data removed)

On examination of the check lap data it was found that Machines 36 and 38 were just outside the criteria for the mean FCF and the removal of a single geophone reading would not bring them within the test criteria. Machine 43 produced FCF values which were much higher than the other machines (off the scale of the graph).

In addition it was seen that Machine 8 and 43 were outside the individual limit for SDDR. On removal of a single geophone measurement on one station the results from Machine 8 fell within the criteria and Machine 43 was just outside of the criteria.

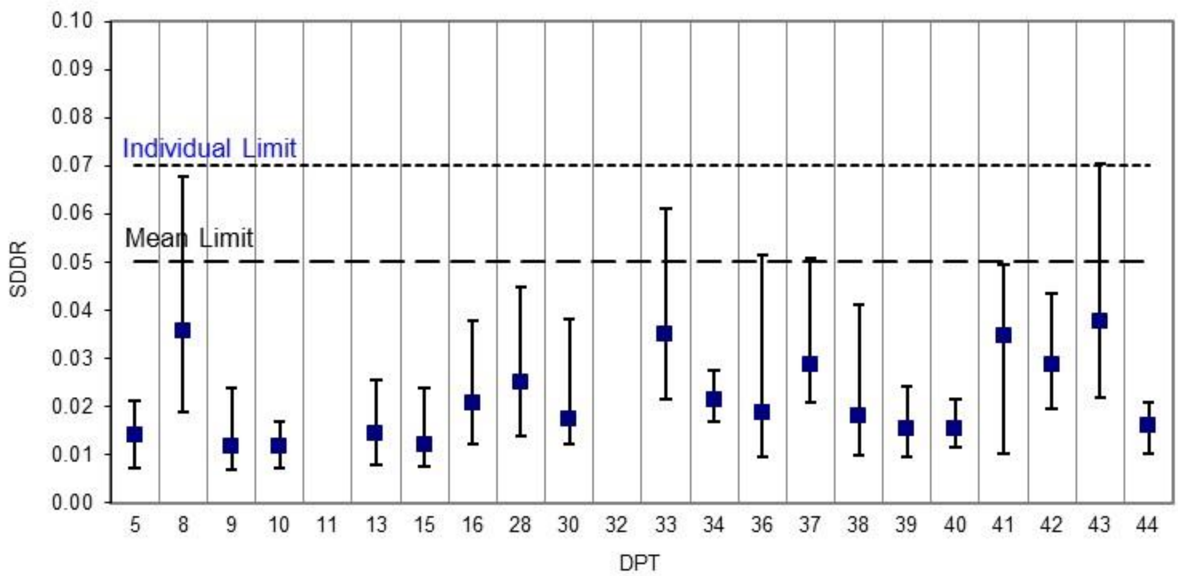

Figure 4.3 Standard deviation of the deviation ratio (SDDR) (check lap, single geophone measurement on one station removed)

The operators of Machines 36, 38 and 43 were notified of these issues so that they could investigate their machine before the main testing on day two.

4.4 Temperature Probes

During the inspection day the operator's temperature probes were compared to the data-loggers using a stabilised environment (a bucket of water). From this testing it was identified that no probes were providing anomalous readings.

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 steadily increased over the day as shown in Figure 5.1.

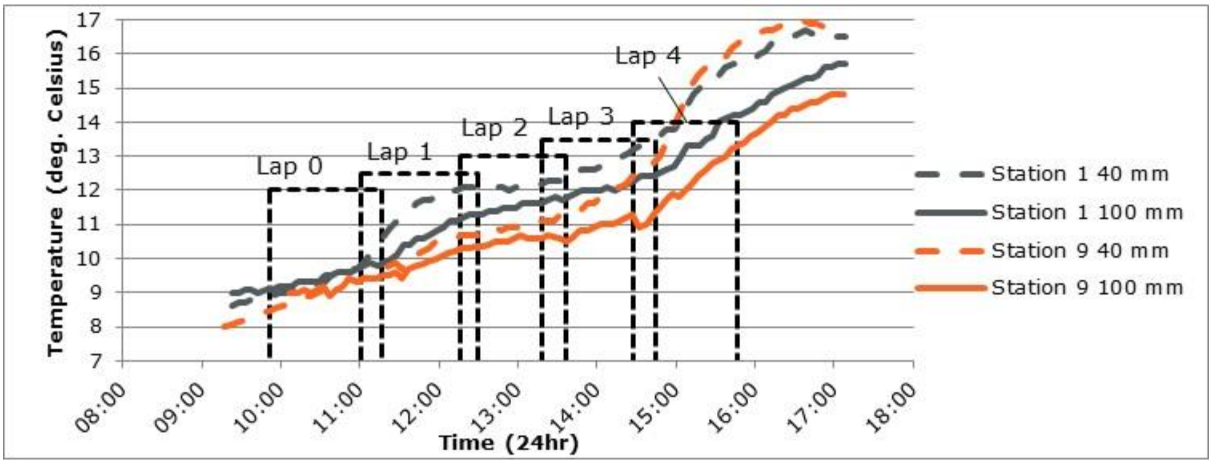

Figure 5.1 Pavement temperatures during main trial day (Day 2)

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.

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	09:52	8.8	9.1	11:17	10.4	9.8	01:25	1.6	0.7
1	11:01	9.7	9.7	12:30	12.1	11.3	01:29	2.4	1.6
2	12:16	12.0	11.1	13:36	12.3	11.7	01:20	0.3	0.6
3	13:18	12.2	11.6	14:45	13.5	12.4	01:27	1.3	0.8
4	14:27	13.1	12.2	15:47	15.7	14.2	01:20	2.6	2.0

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	09:52	8.4	-	11:17	9.7	9.4	01:25	1.3	-
1	11:01	9.3	9.3	12:30	10.7	10.4	01:29	1.4	1.1
2	12:16	10.6	10.2	13:36	11.3	10.6	01:20	0.7	0.4
3	13:18	11.1	10.6	14:45	12.8	11.3	01:27	1.7	0.7
4	14:27	12.2	11.2	15:47	16.2	13.2	01:20	4.0	2.0

It can be seen that the 3°C limit was not exceeded for the 100mm temperature on any lap. Note: the temperature logger at station 9 was found to be disconnected at points during the day. This is the reason for the missing data for Lap 0 on this station for the 100mm depth.

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.

One of the tow vehicles brought by ALC/MoD (Machines 32, 33, 41 and 42) was involved in a traffic incident and was not usable during the trial. They were unable to bring in another tow vehicle. Initially sharing of one of the tow vehicles between Machines 32 and 42 was attempted. However, it soon became apparent that this approach would not work due to the time taken to swap over the machines and the otherwise continuous running of the DPTs at the trial (during the testing around 5-6 machines were queuing at the start point of the lap). ALC/MoD were notified that they would have to choose which three machines would take part in the main testing and the fourth machine would take part in any additional laps conducted towards the end of the day if practical (noting that if any issues were identified with this machine no repeat testing would be undertaken). They decided to exclude Machine 32 from the main testing.

After the initial processing of data, issues were found with the data from some of the machines.

- Machine 8 was on the threshold for the SSDR criteria for individual geophones and met the criteria after removal of a single geophone measurement from one station during Lap 1. However on Lap 2 they did not meet the SSDR criteria for individual geophones even with the removal of a single geophone measurement. They were notified of this issue following the completion of Lap 3 and they added a stabilising bar to improve the repeatability. This machine then went on to produce suitable results for Laps 4 and 5.
- Machine 33 was just outside the threshold for the SDDR criteria for individual geophones, however this occurred for two separate geophones, and therefore could not meet the criteria after removal of a single point. The crew for this machine were notified of this issue prior to Lap 2. They kept the current configuration of the machine but adjusted the software settings on the device. They then went on to produce acceptable data in Laps 2 and 3.
- Machine 36 was now producing FCF values which resulted in the Mean FCF to be slightly too high (it was slightly too low on Day 1). They were notified of this issue after they completed Lap 2 and they adjusted the buffers. They then went on to produce acceptable data in laps 3 and 4.
- Machine 42 did not take part in lap 0 due to swapping the tow vehicle with Machine 32. Therefore Lap 1 was used as the warm-up lap and laps 2 and 3 were used for the assessment.

- Machine 43 now met the Mean FCF criteria, but not the criteria for the FCF of individual geophones (for the geophones which were correctly aligned see section 4.1). In addition it was found that the SDDRs were now outside of the criteria (for the last three geophones and the mean). The crew for Machine 43 swapped around two of the geophones, to see if the performance issue in the FCF criteria was caused by differences in the geophones or if it was related to a more fundamental difference between this device and the fleet (it is a prototype device). Following the change in geophones the same level of performance was achieved.

Machine 32 did not take part in the main testing due issue with the tow vehicle discussed earlier. It did however take part in lap 5 (as the other machines from the same company had carried out the required testing). This machine failed to meet the SDDR criteria for individual geophones.

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 1 and 2 for all machines except for the some of the machines discussed above as shown in Table 5.3.

Table 5.3 Laps used for the assessment other than laps 1 and 2

Machine	Lap i	Lap ii
8	4	5
32	1	5
33	2	3
36	3	4
42	2	3

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

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.

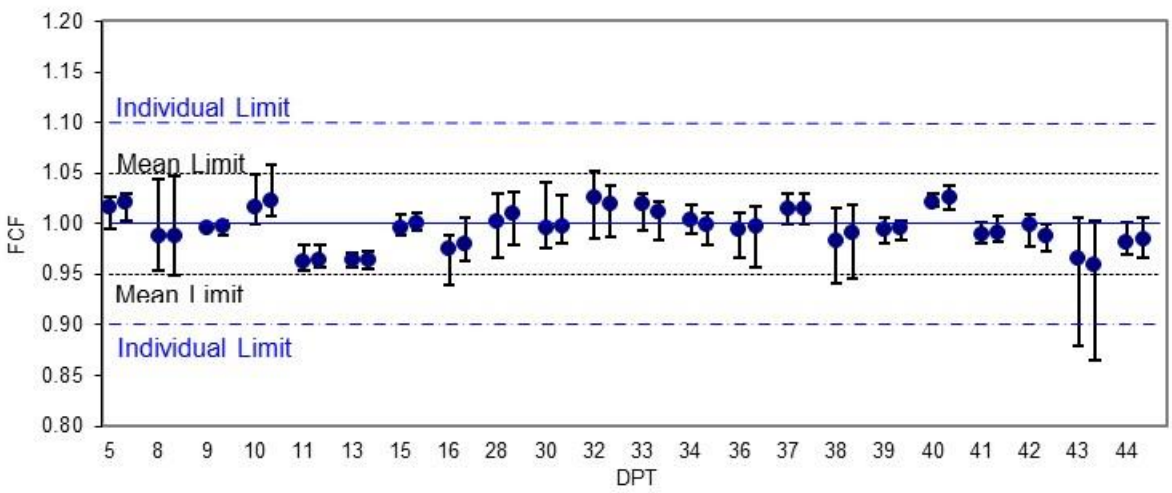

Figure 5.2 Field calibration factors (FCF) for each DPT (main trial day for the chosen test laps, no geophone readings removed)

It can be seen from Figure 5.2 that all twenty-two machines met the trial requirements for Mean Field Calibration Factor (FCF) using the full data set from the two chosen test laps. In addition twenty-one of the machines met the trial requirements for the individual geophone FCF values using the full set of data. Machine 43 did not meet this criteria.

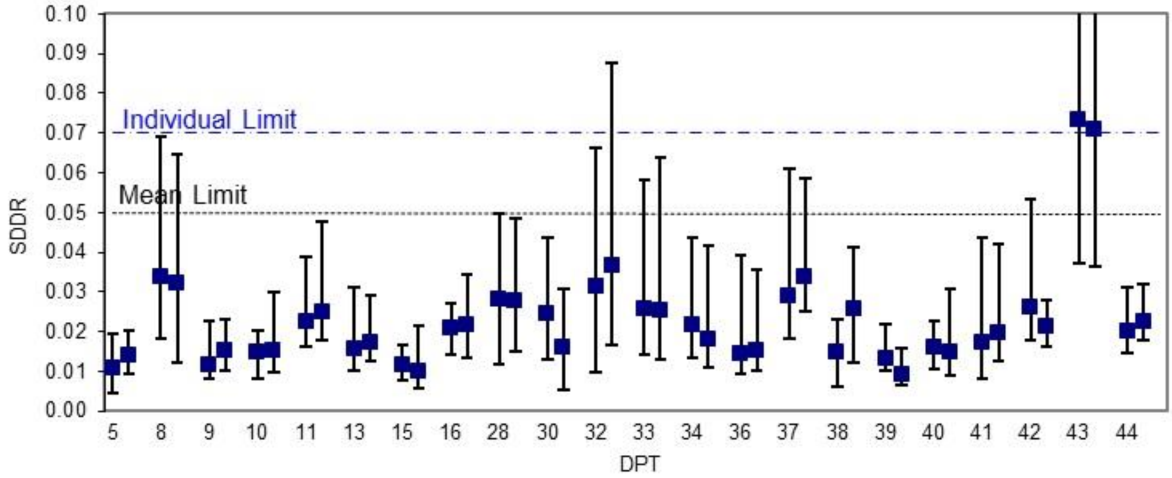

Figure 5.3 Standard deviation of the deviation ratio (SDDR) for each DPT (main trial day for the chosen test laps, no geophone readings removed)

Twenty-one machines passed the criteria for the average 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 43 did not meet this criteria. It can also be seen that Twenty machines passed the criteria for the SDDR of individual geophones using the full set of data. Machines 32 and 43 did not meet this criteria.

5.2.2 Plots of FCF and SDDR (after geophone removal)

The results from laps i and ii (after geophone removal) are shown graphically in Figure 5.4 for FCF and Figure 5.5 for SDDR.

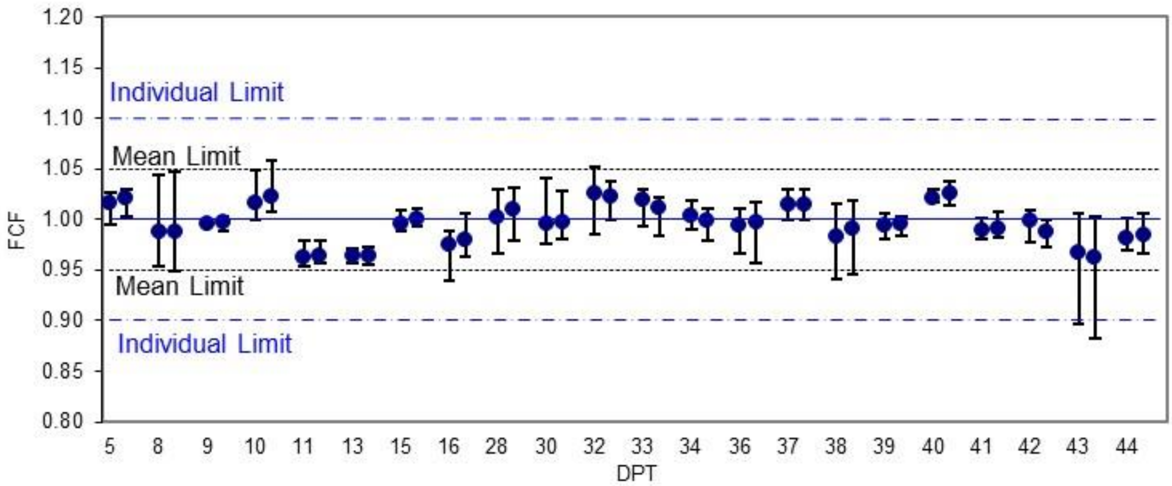

Figure 5.4 Field calibration factors (FCF) for each DPT (main trial day for the chosen test laps, with allowed geophone readings removed)

It can be seen from Figure 5.4 that after the removal of a single geophone reading from one station on each lap Machine 43 still does not meet the FCF requirement for the FCFs of individual geophones.

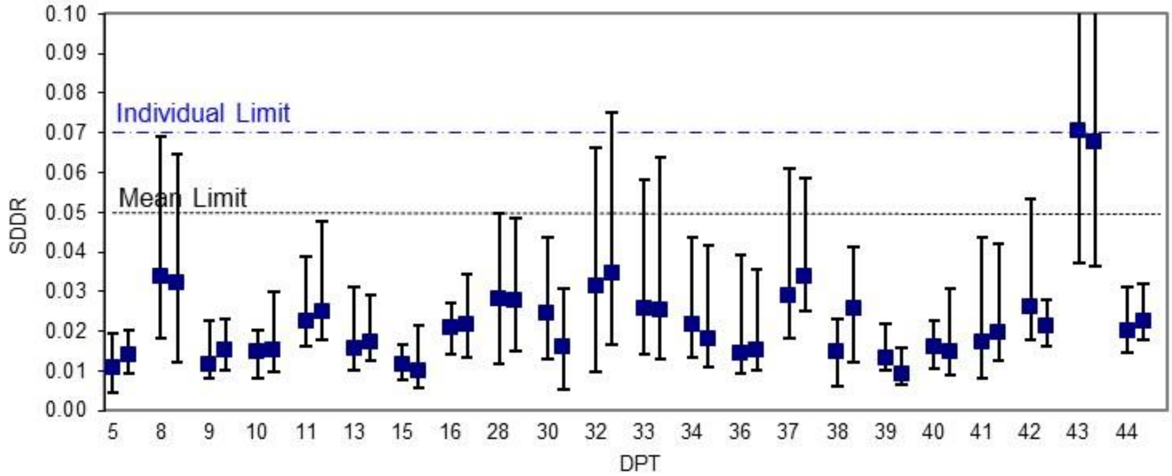

Figure 5.5 Standard deviation of the deviation ratio (SDDR) for each DPT (main trial day for the chosen test laps, with allowed geophone readings removed)

Following the removal of a single geophone reading from one station on each lap it can be seen that the Machines 32 and 43 still do not met the trial criteria for SDDR.

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 486.62m 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 5.4 (negative denotes the operator recorded a shorter length). In this table the data is shown in grey if the difference measured was within or equal to 1m of the reference, and highlighted in bold and red font if the difference measured was greater than the criteria (4.87m). A machine would fail this test if it could not supply three measured lengths within the criteria.

Table 5.4 Difference between operators' measured values and reference

Machine	Difference between measured distance and reference			
	Lap 0	Lap 1	Lap 2	Lap 3
5	-0.6	1.4	2.4	1.4
8	-0.6	-0.6	-0.6	-0.6
9	1.4	1.4	0.4	0.4
10	0.4	0.4	0.4	0.4
11	2.4	1.4	1.4	-1.6
13	-0.6	-0.6	-0.6	-0.6
15	0.4	0.4	0.4	0.4
16	0.4	-0.6	0.4	0.4
28	0.4	0.4	0.4	0.4
30	0.4	0.4	0.4	-0.6
32	No measurement	**158.4**	No measurement	No measurement
33	**157.4**	**7.4**	**7.4**	**6.4**

Machine	Difference between measured distance and reference			
	Lap 0	Lap 1	Lap 2	Lap 3
34	0.4	0.4	0.4	0.4
36	-1.6	-0.6	-0.6	-1.1
37	-0.7	-1.1	-1.0	No measurement
38	1.4	1.4	1.4	0.4
39	0.5	0.4	0.3	0.3
40	1.4	1.4	1.4	1.4
41	1.3	1.1	1.0	1.0
42	No measurement	**136.4**	**166.4**	**166.2**
43	**363.4**	**363.4**	**363.4**	No measurement
44	1.4	1.4	1.4	No measurement

It can be seen from this table that eighteen of the machines meet the trial criteria. In addition, 51% of the measurements were within 1m and 80% of the measurements were within 3m.

5.4 OSGR measurements

3-dimensional position data was supplied by 7 of the 22 machines at the trial. 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 5.5. This data is highlighted in bold and red text if the percentage is below 75% for either criteria.

Table 5.5 Assessment of positional data

Machine	Percentage of data that is within x m of the reference (horizontally)		Performance band
	2m	5m	
9	78	85	High
30	**43**	**55**	Low
33	*Single non UK coordinate reported for all locations.*		*n/a*
36	***4***	***35***	Low
38	**11**	**38**	Low
39	100	100	High
40	83	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 5.6 and Figure 5.7.

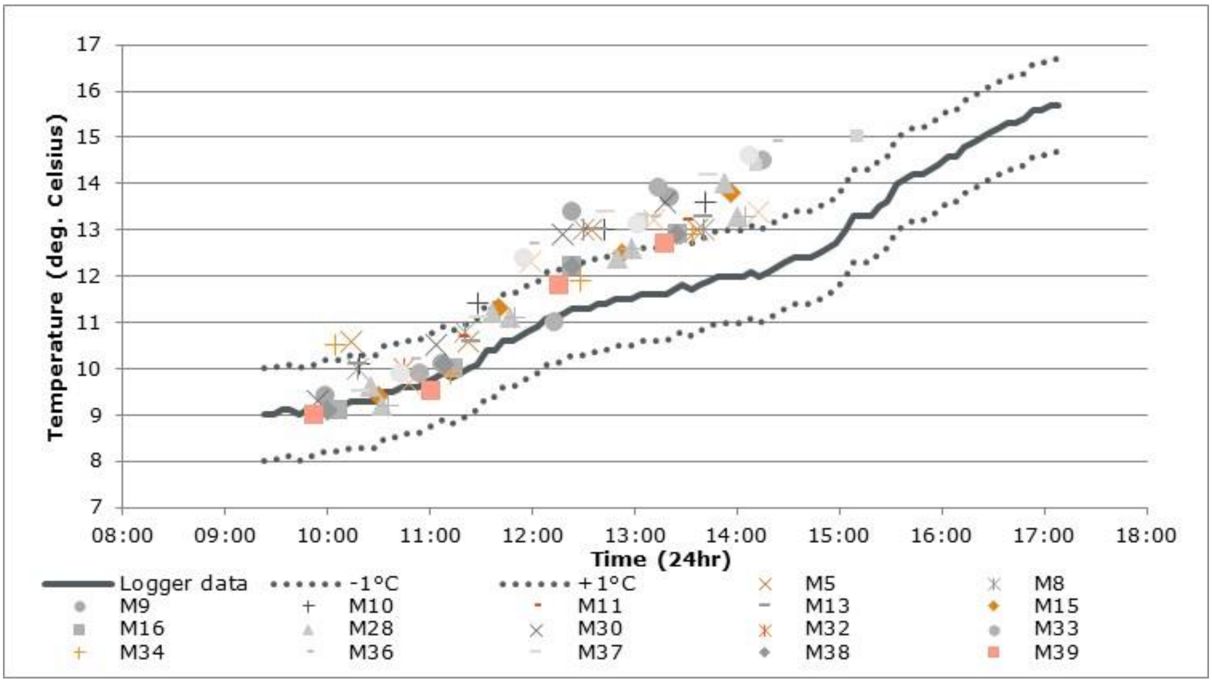

Figure 5.6 Comparison of operators' temperatures and logger temperatures (day 2 near station 1, 100mm depth)

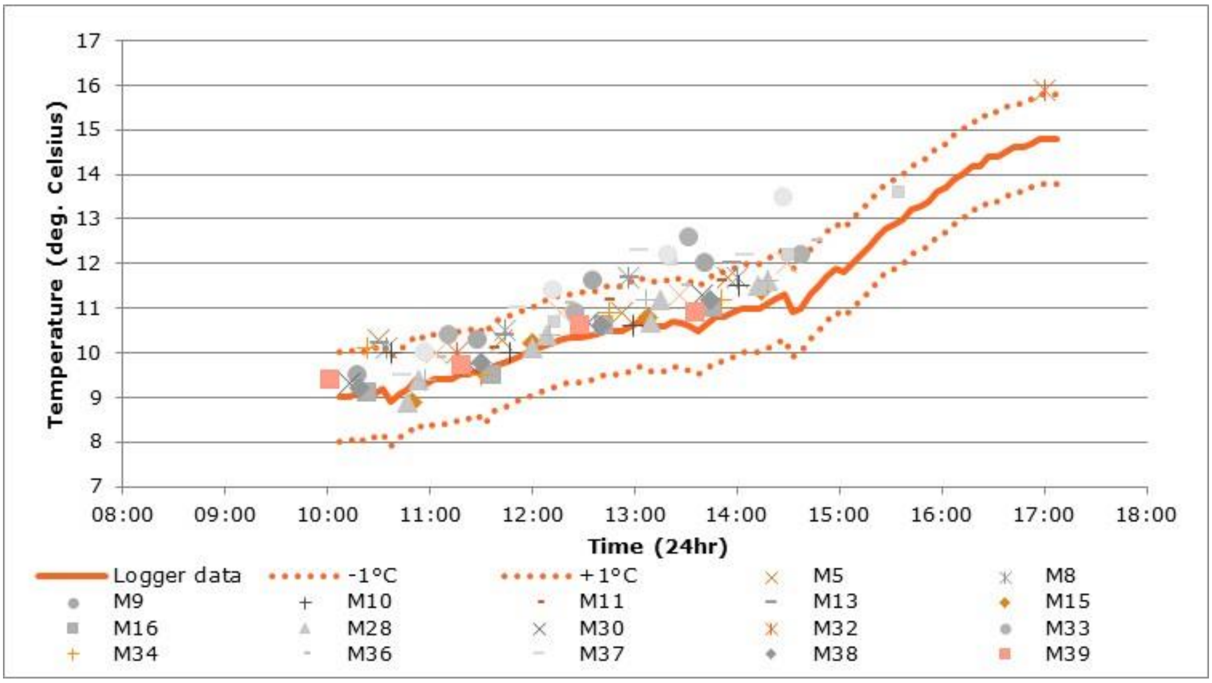

Figure 5.7 Comparison of operators' temperatures and logger temperatures (day 2 near station 9, 100mm depth)

It can be seen from these two plots that although the measurements from the operators are close together they deviate away from the logger measurements, particularly on station 1 for the later part of the day. It was therefore decided that the average of the fleet should be used for this assessment instead of the data logger data. This approach has been used in the Deflectograph accreditation trials when there has been questions on the suitability of the reference data. This data is shown in Figure 5.8 and Figure 5.9.

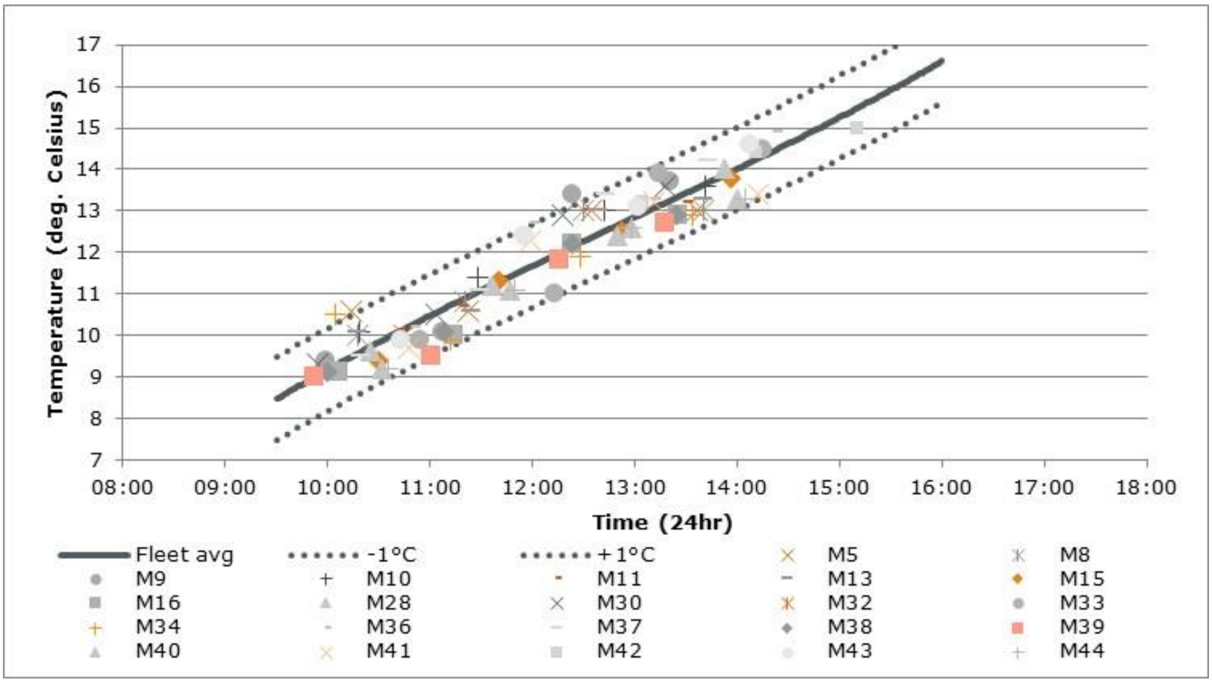

Figure 5.8 Comparison of operators' temperatures and fleet mean (day 2 near station 1, 100mm depth)

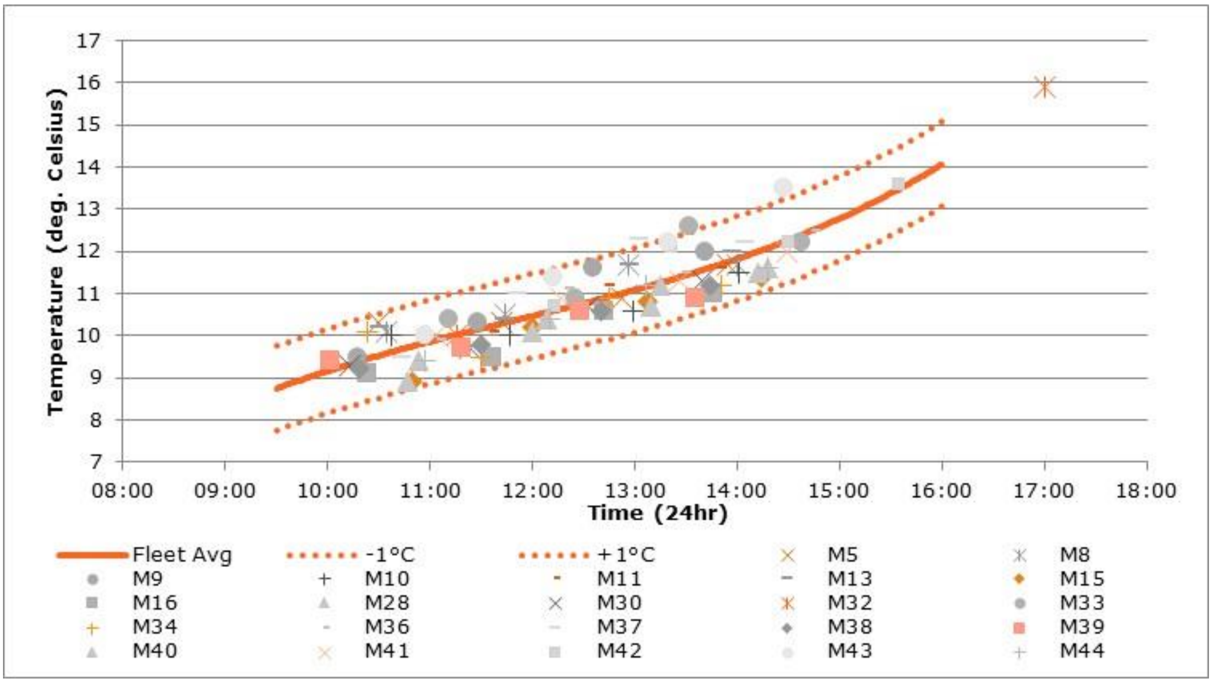

Figure 5.9 Comparison of operators' temperatures and fleet mean (day 2 near station 9, 100mm depth)

It can be seen from these graphs (Figure 5.8 and Figure 5.9) that although the measurements taken by the operators differ from the data loggers, there is good overall consistency in the fleet with only a few points differing by more than 1˚C from the average.

The test criteria for temperature measurement are given in section 3.4, and the machines were assessed using the data from laps 0, 1, 2 and 3. The differences (from the fleet mean) and ratings given are presented in Table 5.6. In the table values are highlighted in bold and red font if the value was more than 1ºC away from the reference.

Table 5.6 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**	0.8	-0.3	0.0	0.7	-0.1	-0.5	0.0	High
8	0.4	0.5	-0.1	0.2	0.8	0.7	-0.6	-0.1	High
9	0.3	0.1	-0.5	0.2	**1.3**	0.8	0.5	0.4	High
10	0.5	0.4	0.4	-0.3	0.5	-0.5	0.0	-0.3	High
11	-0.2	-0.3	-0.1	-0.1	0.7	0.3	-0.2	-0.1	High
13	0.5	0.7	-0.3	0.1	0.6	0.7	-0.3	0.2	High
15	-0.4	-0.8	0.0	-0.3	-0.2	-0.4	-0.1	-0.6	High
16	-0.2	-0.3	-0.7	-0.7	0.1	-0.3	-0.4	-0.6	High
28	-0.1	-0.8	0.0	-0.4	-0.2	-0.5	0.1	-0.5	High
30	0.3	0.0	0.0	-0.4	0.9	-0.1	0.4	-0.2	High
32	-	-	-0.1	0.0	**1.4**	**1.8**	-	-	Low
33	-0.4	0.4	-0.9	0.2	0.8	**1.2**	0.2	-0.2	High
34	**1.2**	0.7	-0.8	-0.7	-0.3	0.0	-0.6	-0.5	High
36	0.0	0.0	**1.1**	0.4	0.3	0.1	0.5	0.0	High
37	-0.1	-0.2	0.1	0.6	0.9	**1.2**	0.5	0.3	High
38	0.0	-0.2	-0.5	-0.4	0.1	-0.3	-0.4	-0.4	High
39	0.0	0.2	-1.0	-0.3	-0.2	-0.1	-0.5	-0.6	High
40	-0.7	-0.4	-0.3	-0.1	-0.2	0.0	-0.7	-0.5	High
41	-0.5	0.1	0.7	0.3	0.2	-0.1	-0.8	-0.2	High
42	-	0.1	0.3	0.8	0.2	-0.1	-0.4	0.1	High
43	-0.2	0.2	0.8	0.8	0.2	0.9	0.4	**1.3**	High
44	-0.7	-0.4	-0.4	-0.2	-0.2	0.0	-0.8	-0.5	High

It can be seen from this table that the majority of the machines achieved the High performance rating. One machine (Machine 32) achieved a Low performance rating, however this low performance was in part due to the fact that the machine only took part in two laps and the missing data has been treated as being outside of the requirements.

5.5.1 Contactless air and surface temperature measurements

There is currently in development a methodology for estimating the temperature at 100mm from measurements of the surface and air temperatures. Therefore a number of contractors have fitted sensors for the automatic measurement of air and surface temperatures to their survey devices. Although not formally part of the accreditation trial this data was collected and examined.

Of the twenty-two machines which took part in the trial, thirteen machines (28, 32, 33, 34, 36, 37, 38, 39, 40, 41, 42, 43 and 44) had surface temperatures in their datasets which changed during testing (i.e. not fixed default values). This data is shown in Figure 5.10. The data is repeated in Figure 5.11 with a reduced scale y axis.

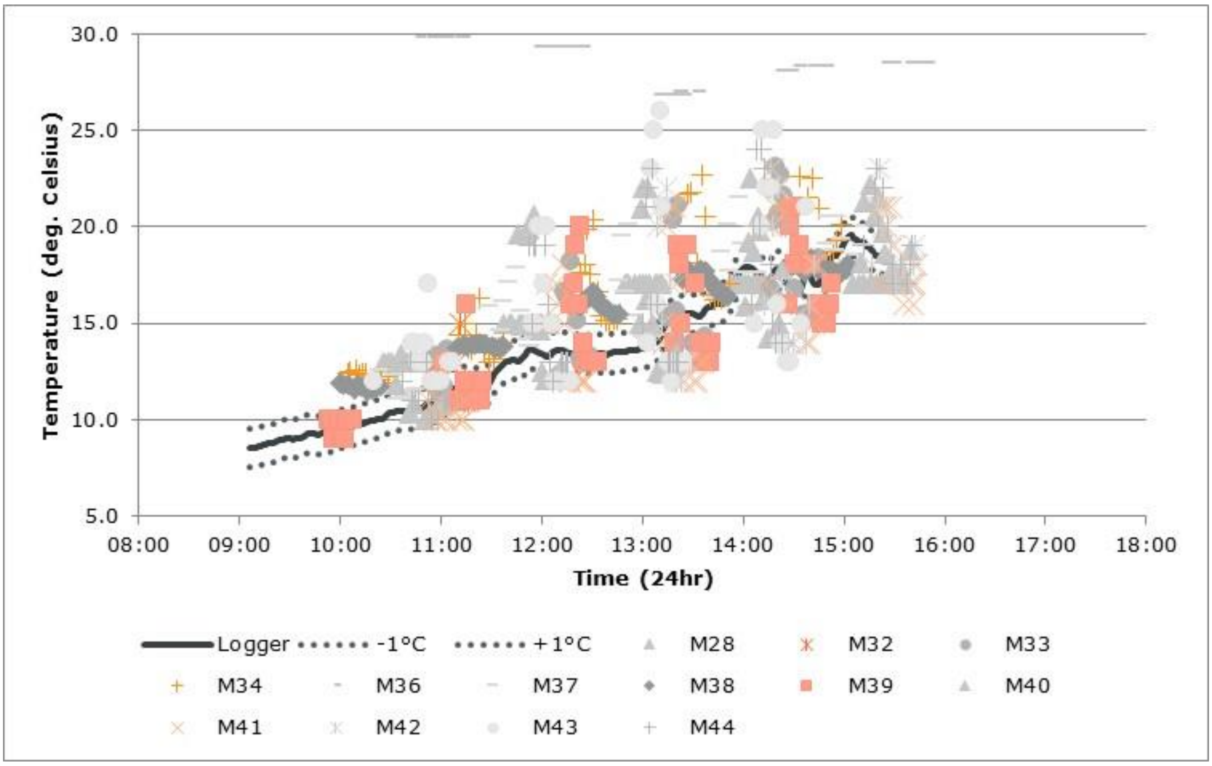

Figure 5.10 Comparison of surface temperatures recorded by DPTs and reference logger measurements

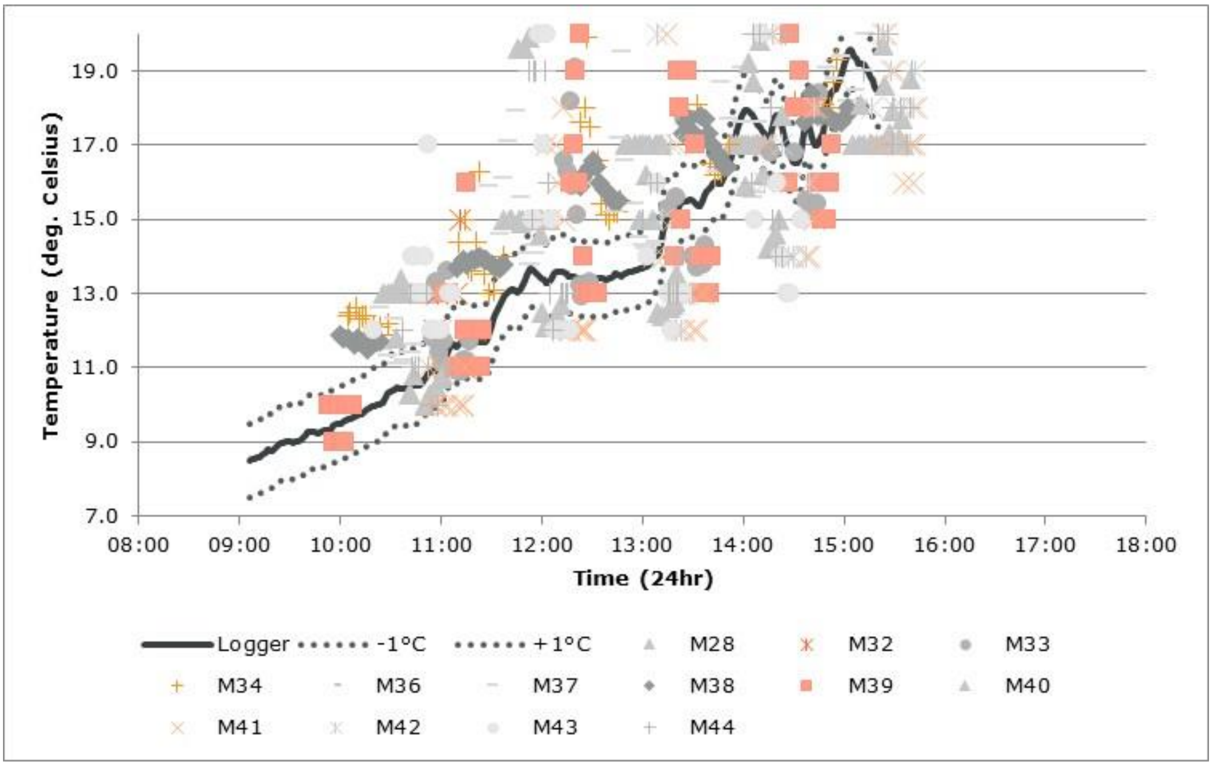

Figure 5.11 Comparison of surface temperatures recorded by DPTs and reference logger measurements

It can be seen from these graphs (Figure 5.10 and Figure 5.11) that there is a significant spread in the data.

Fifteen machines (9, 28, 30, 32, 33, 34, 36, 37, 38, 39, 40, 41, 42, 43 and 44) provided air temperatures in their datasets which changed during testing. This data is shown in Figure 5.12

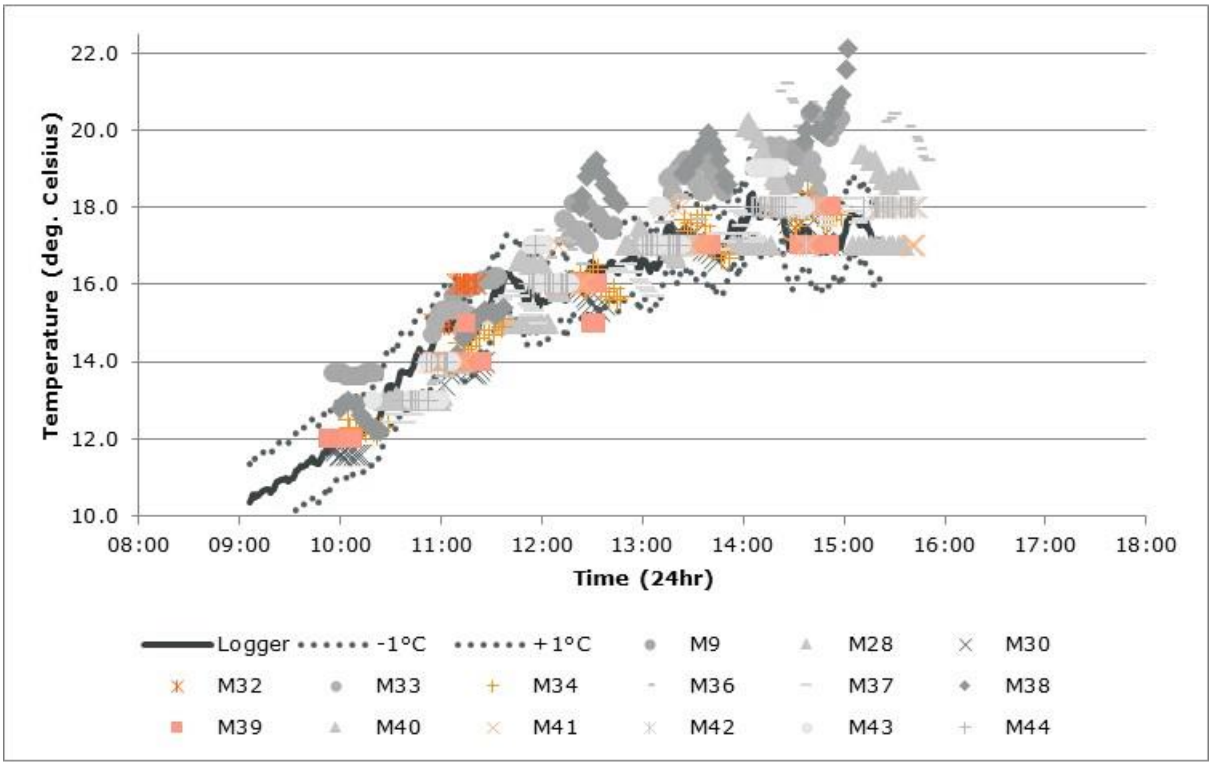

Figure 5.12 Comparison of air temperatures recorded by DPTs and reference logger measurements

It can seen from this graph (Figure 5.12) that the spread of the data is much lower than for surface temperatures with the majority of the data being close to the logger measurements.

It is recommended that these DPT mounted temperature measurement sensors are further assessed at future accreditation trials and the reasons for this wide spread in surface temperatures investigated. In addition if the delivery of air and surface temperature data (or 100mm estimate derived from this data) becomes a permitted option for surveys then a formal assessment should be introduced along with criteria similar to those used for the temperature probe data.

6 Summary of trial findings

The 2015 UK DPT accreditation trial was held at MIRA on the 29th and 30th September 2015. Twenty-two machines took part in the trial. The key findings of the trial are as follows:

- Twenty-one machines met the mandatory trial requirements for the average and individual geophone Field Calibration Factors (FCF) without removing any individual geophone readings. The remaining machine met the requirements for the average FCF but did not meet the criteria for the individual FCFs (even with a single geophone measurement on one station on each lap removed).
- Twenty machines met the mandatory trial requirements for the average and individual geophone Standard Deviation of the Deviation Ratio (SDDR) without removing any individual geophone readings. One machine met the average requirement but not individual SDDR requirement. The remaining machine did not meet either SDDR requirement.
- Eighteen machines met the mandatory trial requirements for elapsed distance measurement.
- Twenty machines achieved a high performance rating in all three of the non-mandatory criteria with regards to repeatability. Two machines did not take part in this test.
- Twenty-one machines achieved a high performance rating in the non-mandatory temperature measurement criterion. One machine achieved a low rating.
- Seven machines provided GPS data. The machines were only assessed for horizontal reproducibility and three achieved a high rating, and three a low rating. The remaining machine provided invalid data.

Overall, all eighteen machines that participated in the 2015 accreditation trial fully met the mandatory requirements of the trial.

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

Although not formally assessed at the trial, data from the measurement of air and surface temperature sensors fitted to some of the machines was collected and investigated. It was found that the surface temperature measurements were quite variable, however the air temperature measurements were reasonably consistent. It is recommended that the performance of these DPT mounted temperature measurement sensors are further assessed at future accreditation trials. In addition, if the delivery of air and surface temperature data (or a 100mm depth estimate derived from the data) becomes an accepted option then a formal assessment should be introduced along with criteria similar those used for the temperature probe data.

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

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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	AECOM Ltd.	Dynatest HWD 8082 SN 050	Trailer	2/5	2-way Segmented	21/03/2015	06/09/2015	24/09/2015
8	AECOM Ltd.	Dynatest FWD 8002 SN 028	Trailer	6/3	2-way Segmented	**Not supplied**	13/09/2015	16/09/2015
9	PMS Ltd.	Dynatest 8002 FWD SN 136	Trailer	4/2	2-way Segmented	02/09/2015	02/09/2015	**September 2015***
10	AECOM Ltd.	Dynatest FWD 8002 SN 192	Trailer	6/3	2-way Segmented	12/03/2015	27/09/2015	12/09/2015
11	Forth Crossing Bridge Constructors JV	Dynatest FWD 8002 SN 187	Trailer	3/1	Solid	03/09/2015	03/09/2015	03/09/2015
13	AECOM Ltd.	Dynatest HWD 8082 SN 029	Trailer	2/5	Solid	10/03/2015	06/09/2015	17/02/2015
15	CET Infrastructure	Dynatest FWD 8002 SN 203	Trailer	6/3	2-way Segmented	**June 2015***	**June 2015***	**June 2015***
16	PTS	Dynatest FWD 8002 SN 214	Trailer	5/2	2-way Segmented	21/09/2015	21/09/2015	21/09/2015
28	Pulse Surveying Ltd.	Dynatest FWD 8002 SN 271	Trailer	5/2	Solid	07/05/2015	04/09/2015	28/08/2015
30	PMS Ltd.	Dynatest 8002 FWD SN 173	Trailer	5/2	Solid	17/09/2015	04/09/2015	10/03/2015
32	ALC (MoD)	Dynatest HWD 8082 SN 069	Trailer	0/4	Solid	11/08/2015	12/08/2015	08/09/2015
33	ALC (MoD)	Dynatest HWD 8082 SN 070	Trailer	0/4	Solid	19/08/2015	19/08/2015	29/07/2015
34	PTS	Dynatest HWD 8082 SN 108	Trailer	1/2	4-way Segmented	10/08/2015	10/08/2015	10/08/2015

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
36	TestConsult Ltd.	Grontmij FWD PRI2500 SN 0608-303	Trailer	3/8	4-way Segmented	17/05/2015	18/12/2014	17/12/2014
37	Stanger Testing	Dynatest FWD 8002 SN 352	Trailer	6+1/3	4-way Segmented	14/08/2015	14/08/2015	01/09/2015
38	Seamus O'Reilly	Grontmij FWD PRI1500 SN 1111-448	Trailer	3/8	4-way Segmented	10/09/2015	16/09/2015	10/09/2015
39	TRL	Dynatest FWD 8002 SN 388	Trailer	6/3	Segmented	28/09/2015	28/09/2015	06/05/2015
40	Dynatest	Dynatest FWD 8012 SN 002	Trailer	4/2	4-way Segmented	10/11/2014	10/11/2014	7/10/2014
41	ALC (MoD)	Dynatest HWD 8082 SN 145	Trailer	0/4	2-way Segmented	14/09/2015	14/09/2015	14/09/2015
42	ALC (MoD)	Dynatest HWD 8082 SN 149	Trailer	0/4	2-way Segmented	07/09/2015	07/09/2015	07/09/2015
43	Pavetesting	PaveTesting 074PT0715 FWD	Trailer	10/4	4-way Segmented	**1 week before trial***	**1 week before trial***	**September 2015***
44	Dynatest	Dynatest HWD 8082 SN 156	Trailer	0/4	4-way Segmented	**Not supplied**	**Not supplied**	29/08/2015

* 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 2015 Accreditation trial - Instructions to operators

The 2015 Dynamic Plate test (DPT) accreditation trial is carried out as a prerequisite to operating FWD and HWD devices under Highways England 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.

D.1 Additions for the 2015 accreditation trial

D.1.1 Check on temperature probes

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.2 Prior to trial

D.2.1 Machine checks and Inspection sheets

Please perform your QA checks, routine inspections and any other relevant checks for your machine to reduce the chances of any issues occurring during the trial. The QA procedure for DPT devices operating on the Highways England road network is given in "Accreditation and Quality Assurance of Dynamic Plate Test Devices" available on the PCIS web site (http://www.pcis.org.uk/index.php?p=6/12/0/detail,0,926).

You will also be supplied with inspection sheets which will need to be completed and returned to TRL prior to the trial. These sheets will form the basis of the machine inspections conducted on day 1 of the trial.

D.2.2 Geophone positions and machine set up

The operation of the DPTs 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).

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/F25 files (and the geophones are in the correct order).

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

D.2.3 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.2.4 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 at least two weeks beforehand. These will be passed to MIRA security and used to produce yellow test track access permits.

D.3 Trial Outline

The trial will last for **2 days** and takes place between the **29th and 30th of September 2015**. The morning of the **1st October may also be required as a contingency for bad weather** or other unforeseen circumstances.

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.

D.4 General requirements during trial

D.4.1 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.4.2 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.4.3 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. In addition MIRA require vehicle headlights to be switched on whenever you are moving around the test track.

D.4.4 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.4.5 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.10.

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.5 Day 1 (Tuesday 29th September) - Machine inspection, distance calibration and initial testing

D.5.1 Arrival at MIRA

Please **arrive at the MIRA site by 09:00**, directions to MIRA are provided in D.8.

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.

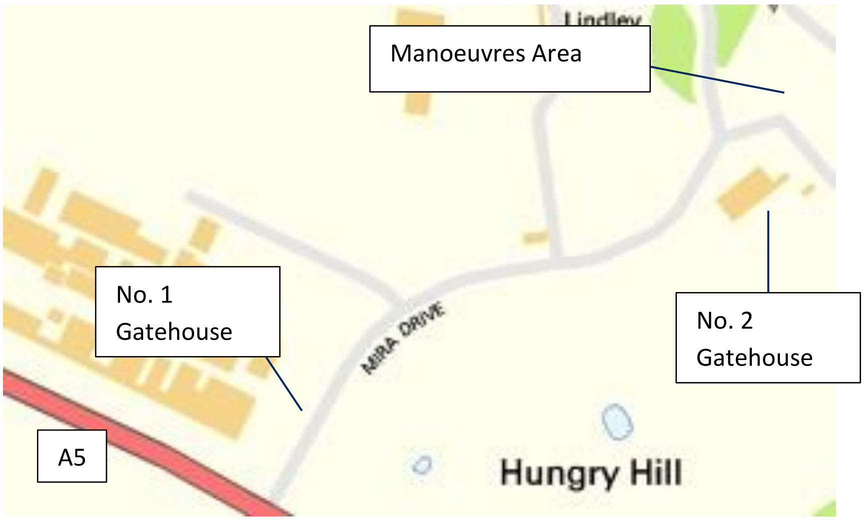

Figure 13: Access to MIRA

D.5.2 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.2.1).

During this time your temperature probe will also be collected for the "water bucket" test. The "water bucket" test involves allowing the collected temperature probes to equalise to the same temperature (using a water bucket or similar). Any differences in the reported measurements will be noted and fed back to the operators and used to aid advice on any low performance in the temperature measurements on the main trial day. Note: the water bucket test is for additional information and will not have any test criteria attached to it. The temperature probes will be returned after the initial reproducibility test lap, therefore please **make sure that your temperature probe has a suitable identifying mark** so that you can identify which one is yours when collecting the device.

D.5.3 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 2). 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.

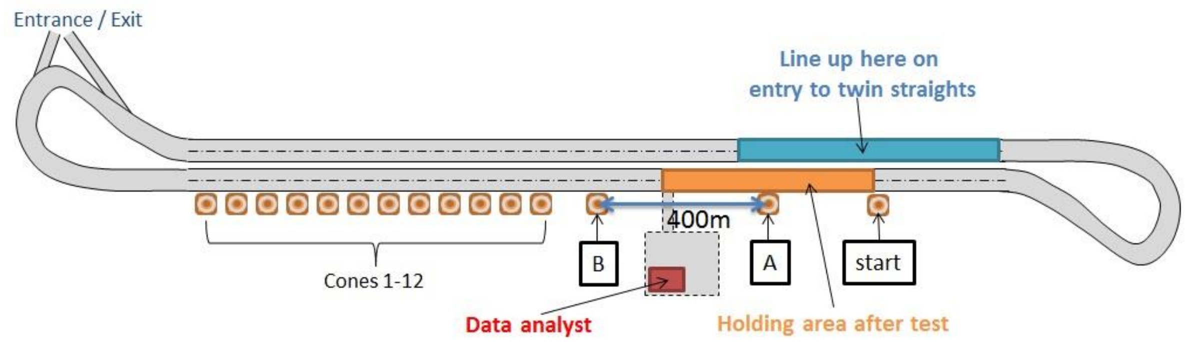

Figure 2: Distance Calibration and initial reproducibility test

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 or MMFAM.F25, where: *MM* = Machine Trial Number (see D.10)

On completion of the pre main testing lap stop in the holding area (orange area in Figure) and hand in your data to the data analyst. The data analyst will be located in the location shown on Figure . 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 as soon as possible, and they will arrange for you to redo the calibration or testing at a suitable time.

D.5.4 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).

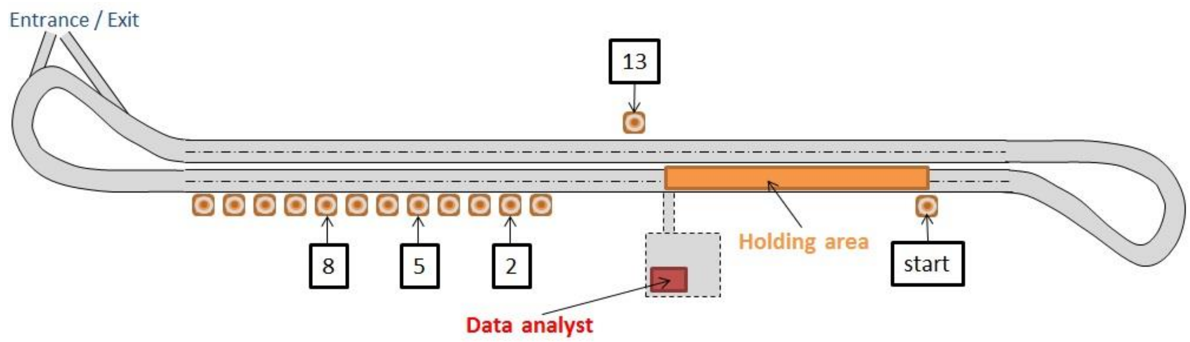

Figure 3: Repeatability lap

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 or MMREPEAT.F25, where: *MM* = Machine Trial Number (see D.10)

On completion of the repeatability test stop in the holding area (orange area in Figure 3) 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.6 Day 2 (Wednesday 30th September) – 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 .

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

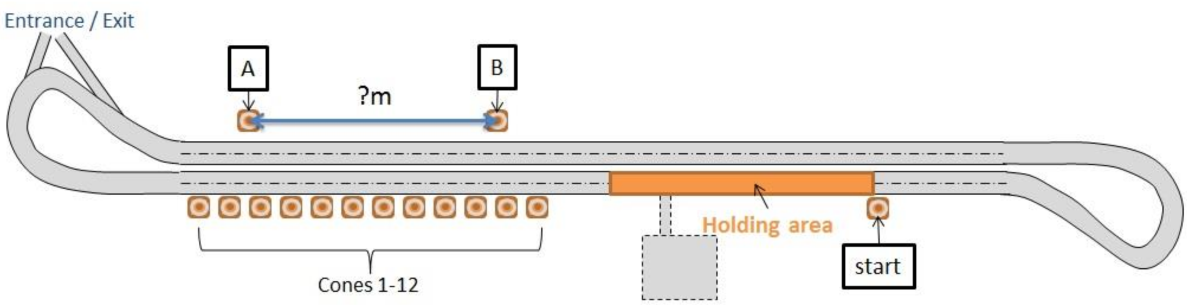

Figure 4: Main day testing

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 or MMLLACC.F25, where: *MM* = Machine Trial Number and *LL* = Run number (see D.10)
- 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.7 Day 3 (Thursday 1st October) –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.7.1 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.8 Directions to MIRA

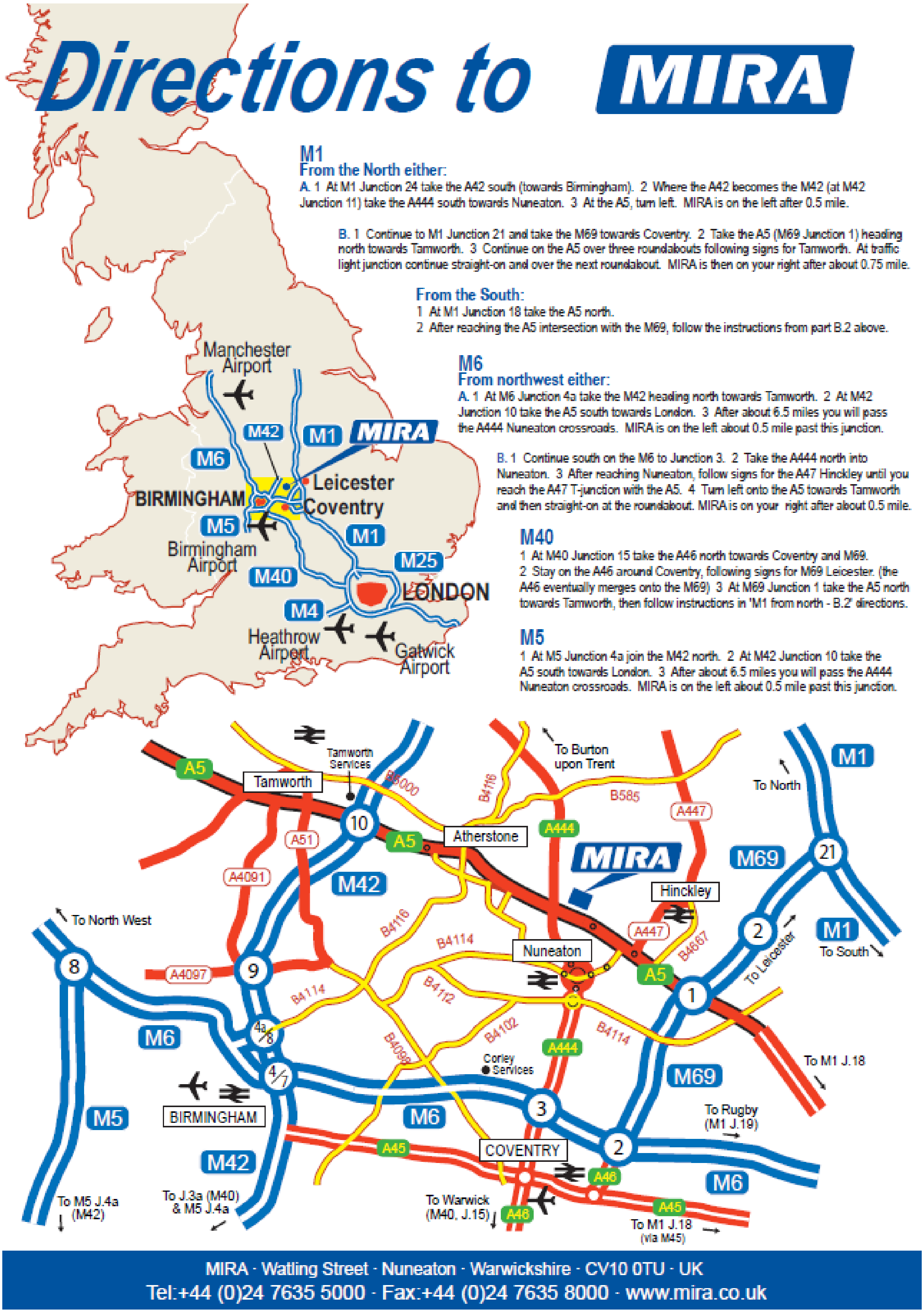

Figure 5: MIRA location

D.9 DPT 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" or ".F25" format.

Please ensure you bring along a calibrated temperature probe 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 DPT 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.9.1 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.9.2 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.10 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	69	59	53	46	40	33	23	0.5	0.4	0.3	0.3	0.2	0.2	0.1
5	464	376	237	143	84	50	30	0.5	0.6	0.4	0.4	0.4	0.3	0.4
8	235	204	166	126	92	65	33	0.5	0.4	0.3	0.5	0.2	0.3	0.5
13	117	105	90	76	62	49	30	0.4	0.5	0.3	0.3	0.2	0.4	0.4

A.2 Machine 8

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	76	63	57	50	41	35	25	0.1	0.3	0.1	0.2	0.3	0.3	0.3
5	497	381	237	140	77	45	26	0.5	0.4	0.3	0.2	0.1	0.1	0.2
8	249	218	173	131	93	66	32	0.6	0.6	0.4	0.4	0.3	0.3	0.4
13	124	111	95	80	64	50	29	0.6	0.6	0.5	0.5	0.5	0.3	0.2

A.3 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	58	52	45	39	33	22	0.3	0.2	0.2	0.2	0.2	0.2	0.2
5	471	368	236	141	82	49	31	1.7	1.1	0.5	0.5	0.4	0.2	0.2
8	223	199	160	122	89	63	33	0.5	1.3	0.4	0.2	0.2	0.2	0.4
13	110	101	86	73	59	47	28	0.3	0.3	0.4	0.2	0.4	0.2	0.3

A.4 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	71	60	54	47	40	33	22	0.3	0.2	0.1	0.4	0.4	0.2	0.2
5	473	371	234	139	81	47	28	0.8	0.6	0.3	0.2	0.5	0.3	1.1
8	234	203	164	126	92	64	33	0.3	0.3	0.2	0.5	0.4	0.3	0.6
13	119	105	91	79	65	49	25	0.2	0.3	0.1	0.2	0.1	0.4	0.4

A.5 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	74	64	57	49	43	36	24	0.3	0.2	0.2	0.2	0.3	0.2	0.4
5	486	396	251	151	85	50	30	1.1	0.9	1.1	0.3	0.3	0.2	0.3
8	252	222	178	135	97	68	34	0.6	0.5	0.4	0.3	0.4	0.4	0.3
13	126	112	96	81	66	53	30	0.4	0.3	0.3	0.5	0.3	0.3	0.4

A.6 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	73	64	57	50	43	36	24	1.5	0.5	0.4	0.1	0.5	0.5	0.3
5	479	385	246	147	85	51	31	0.6	0.5	0.4	0.4	0.3	0.2	0.5
8	246	214	170	129	95	70	36	1.5	0.7	0.5	0.5	0.7	1.1	0.6
13	127	113	94	82	68	58	33	0.9	0.2	0.6	0.6	0.5	1.0	0.6

A.7 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	68	61	55	48	41	34	23	0.2	0.3	0.1	0.1	0.1	0.1	0.2
5	479	385	243	145	83	49	31	0.6	0.5	0.2	0.2	0.2	0.2	0.5
8	242	212	170	128	94	66	32	0.5	0.5	0.3	0.3	0.6	0.5	1.0
13	120	109	94	78	64	50	29	0.3	0.5	1.2	0.7	0.7	0.4	0.3

A.8 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	71	63	56	49	41	35	25	0.8	0.8	0.4	0.9	0.6	1.0	1.1
5	470	390	250	147	85	50	32	2.4	2.5	1.9	1.3	0.6	1.5	1.4
8	244	213	172	129	94	66	36	1.5	1.3	1.1	0.8	1.7	1.0	1.6
13	123	110	95	78	65	47	27	1.4	0.9	0.4	1.1	1.4	1.0	0.6

A.9 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	71	70	52	52	39	33	22	0.1	1.7	0.8	0.9	0.3	0.3	0.2
5	477	370	236	141	81	49	32	0.9	1.2	1.5	1.5	0.2	0.2	0.4
8	234	207	165	131	90	64	32	0.6	0.6	0.5	0.8	0.4	0.4	0.4
13	122	106	92	78	62	49	29	0.5	0.3	0.3	0.3	0.3	0.8	0.3

A.10 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	71	62	56	49	42	36	22	0.2	0.3	0.3	0.2	0.2	0.8	0.5
5	484	381	245	144	82	50	30	1.3	1.0	0.7	0.5	0.4	0.6	0.7
8	248	211	173	130	93	66	33	0.4	0.8	0.3	0.2	0.2	0.7	0.9
13	120	106	92	76	59	53	25	0.3	0.5	0.3	0.2	0.6	1.0	1.1

A.11 Machine 32

Did not take part in the Repeatability assessment.

A.12 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	69	59	53	46	39	33	22	0.2	0.1	0.3	0.1	0.3	0.1	0.3
5	466	375	244	145	86	53	37	1.0	1.2	0.6	0.7	0.3	0.4	1.0
8	235	207	167	125	91	65	35	0.4	0.6	0.9	0.2	0.4	0.4	0.5
13	117	103	90	75	61	48	29	0.5	0.3	0.3	0.5	0.6	0.7	1.0

A.13 Machine 34

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	70	62	54	49	41	34	22	0.3	0.3	0.2	0.3	0.1	0.2	0.2
5	522	383	245	143	85	53	35	3.6	2.3	1.6	1.0	0.7	0.6	0.6
8	245	217	174	130	95	67	34	1.4	1.2	1.0	0.7	0.5	0.4	0.2
13	115	107	90	76	61	50	27	0.8	0.6	0.6	0.5	0.4	0.4	0.3

A.14 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	63	55	49	44	37	32	22	0.1	0.2	0.1	0.1	0.2	0.1	0.1
5	428	326	217	131	75	47	28	0.5	0.5	0.3	0.2	0.2	0.2	0.2
8	212	185	150	116	84	61	32	0.3	0.3	0.3	0.2	0.1	0.1	0.1
13	109	97	85	72	58	48	29	0.1	0.1	0.1	0.1	0.1	0.1	0.1

A.15 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	68	59	53	46	39	32	22	0.2	0.4	0.1	0.4	0.2	0.4	0.1
5	476	387	246	146	85	52	34	0.6	0.8	0.5	0.4	0.2	0.2	0.1
8	236	208	166	125	91	65	34	0.3	0.5	0.8	0.2	0.3	0.3	0.3
13	116	104	89	74	60	48	27	0.3	0.5	0.2	0.8	0.2	0.9	0.2

A.16 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	75	65	58	52	45	39	24	0.1	0.1	0.1	0.1	0.2	0.1	0.1
5	480	387	255	154	90	55	31	0.6	0.4	0.4	0.2	0.2	0.2	0.2
8	247	217	176	135	99	72	35	0.3	0.3	0.3	0.2	0.2	0.2	0.2
13	125	113	98	83	68	55	31	0.1	0.2	0.1	0.1	0.1	0.2	0.1

A.17 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	69	61	55	48	40	35	24	0.5	0.5	1.0	0.7	0.3	0.4	0.9
5	499	381	243	143	82	51	32	1.8	0.6	0.6	0.5	0.5	1.1	1.0
8	238	206	165	124	90	65	34	1.4	0.8	1.0	0.8	0.6	0.9	0.7
13	109	101	88	73	60	48	30	1.0	0.8	0.3	0.4	0.5	0.5	1.0

A.18 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	68	60	53	46	40	33	22	0.3	0.1	0.2	0.3	0.1	0.2	0.2
5	472	376	243	141	83	50	34	0.9	0.4	0.4	0.3	0.5	0.3	0.5
8	238	210	169	126	93	65	33	0.6	0.2	0.2	0.2	0.2	0.1	0.1
13	115	105	90	75	61	48	29	0.5	0.2	0.2	0.2	0.2	0.2	0.2

A.19 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	73	63	56	49	42	35	23	0.3	0.2	0.5	0.3	0.1	0.6	0.3
5	499	374	241	143	80	50	33	1.8	1.6	1.0	0.8	0.5	1.0	0.5
8	250	219	175	133	97	67	34	0.9	0.6	0.6	0.7	0.4	0.6	0.3
13	123	111	95	78	64	50	31	0.6	0.6	0.9	0.3	0.5	0.2	0.5

A.20 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	73	62	55	48	41	34	22	0.1	0.3	0.5	0.1	0.0	0.0	0.6
5	460	373	241	146	85	50	31	0.7	0.6	0.9	0.5	0.6	0.7	0.0
8	253	219	174	132	96	67	34	1.0	0.3	0.3	0.3	0.5	0.4	0.3
13	121	109	93	78	65	54	36	0.6	0.1	0.4	0.5	0.7	0.7	0.0

A.1 Machine 43

Data supplied by Machine 43 was invalidated due to the deflections being significantly lower than the other machines, and was not recollected due to performance during the main trial day.

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	36	30	28	24	21	17	12	0.4	0.3	0.5	0.1	0.5	0.1	0.1
5	270	209	141	84	56	33	25	1.4	1.4	0.7	0.6	0.5	0.3	0.5
8	129	111	92	68	52	33	20	0.8	0.6	0.6	0.5	0.5	0.6	0.5
13	60	53	47	38	32	23	16	0.6	0.6	0.7	0.6	0.4	0.4	0.5

A.1 Machine 44

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	73	63	56	48	42	36	24	0.3	0.5	0.2	0.8	0.6	0.1	0.3
5	499	380	242	141	84	51	32	1.7	1.2	0.8	1.2	0.4	0.7	0.6
8	249	215	174	128	95	68	35	0.8	0.5	0.8	0.9	0.4	0.6	0.5
13	122	109	93	77	63	51	29	0.6	0.8	0.7	0.8	0.5	0.8	0.6

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 2015 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*	*1.022*	*1.021*	*1.018*	*1.015*	*1.011*	*1.009*	*0.994*	*1.013*	*0.017*	*0.010*	*0.007*	*0.010*	*0.010*	*0.014*	*0.018*	*0.012*
	1	Y	1.026	1.027	1.022	1.016	1.010	1.014	0.994	1.015	0.018	0.005	0.005	0.010	0.009	0.011	0.020	0.011
	2	Y	1.028	1.030	1.023	1.022	1.014	1.021	1.003	1.020	0.010	0.009	0.011	0.013	0.015	0.020	0.018	0.014
	3	*N*	*1.031*	*1.032*	*1.031*	*1.028*	*1.017*	*1.024*	*1.011*	*1.025*	*0.013*	*0.008*	*0.011*	*0.012*	*0.016*	*0.017*	*0.018*	*0.013*
	4	*N*	*1.019*	*1.027*	*1.023*	*1.023*	*1.016*	*1.018*	*1.007*	*1.019*	*0.015*	*0.008*	*0.010*	*0.010*	*0.009*	*0.012*	*0.020*	*0.012*
	5	*N*	*1.023*	*1.021*	*1.020*	*1.012*	*1.007*	*1.020*	*1.011*	*1.016*	*0.017*	*0.012*	*0.012*	*0.014*	*0.018*	*0.020*	*0.023*	*0.017*
8	*0*	*N*	*0.945*	*0.956*	*0.962*	*0.969*	*1.001*	*0.993*	*1.031*	*0.979*	*0.023*	*0.020*	*0.029*	*0.026*	*0.030*	*0.050*	*0.067*	*0.035*
	1	*N*	*0.943*	*0.959*	*0.968*	*0.968*	*0.993*	*0.994*	*1.024*	*0.978*	*0.027*	*0.021*	*0.022*	*0.028*	*0.034*	*0.047*	*0.072*	*0.036*
	2	*N*	*0.949*	*0.957*	*0.972*	*0.973*	*0.996*	*1.005*	*1.033*	*0.984*	*0.019*	*0.026*	*0.019*	*0.025*	*0.035*	*0.043*	*0.097*	*0.038*
	3	*N*	*0.955*	*0.958*	*0.978*	*0.971*	*0.997*	*1.002*	*1.058*	*0.988*	*0.018*	*0.022*	*0.029*	*0.031*	*0.034*	*0.049*	*0.083*	*0.038*
	4	Y	0.953	0.962	0.967	0.977	0.996	1.010	1.044	0.987	0.022	0.018	0.020	0.023	0.035	0.049	0.069	0.034
	5	Y	0.949	0.959	0.971	0.975	0.996	1.023	1.047	0.988	0.021	0.012	0.019	0.028	0.031	0.049	0.065	0.032
9	*0*	*N*	*0.996*	*1.000*	*1.000*	*1.002*	*0.991*	*1.000*	*0.987*	*0.997*	*0.014*	*0.013*	*0.010*	*0.011*	*0.013*	*0.013*	*0.024*	*0.014*
	1	Y	0.995	0.998	0.999	0.996	0.992	0.993	0.994	0.995	0.011	0.008	0.011	0.009	0.009	0.011	0.024	0.012
	2	Y	1.001	0.998	0.996	0.996	0.993	1.003	0.989	0.996	0.023	0.011	0.013	0.014	0.010	0.018	0.017	0.015
	3	*N*	*1.014*	*0.996*	*1.000*	*1.004*	*0.994*	*1.004*	*0.992*	*1.000*	*0.023*	*0.012*	*0.010*	*0.011*	*0.007*	*0.011*	*0.024*	*0.014*
	4	*N*	*1.002*	*0.998*	*1.000*	*1.008*	*1.004*	*1.003*	*0.995*	*1.001*	*0.025*	*0.014*	*0.012*	*0.007*	*0.010*	*0.008*	*0.026*	*0.015*
	5	*N*	*0.984*	*0.987*	*0.990*	*0.996*	*0.997*	*1.008*	*0.991*	*0.993*	*0.018*	*0.009*	*0.009*	*0.009*	*0.010*	*0.012*	*0.024*	*0.013*
10	*0*	*N*	*1.008*	*1.015*	*1.015*	*1.017*	*0.992*	*1.024*	*1.048*	*1.017*	*0.014*	*0.008*	*0.009*	*0.016*	*0.019*	*0.017*	*0.029*	*0.016*
	1	Y	1.004	1.017	1.014	1.007	0.999	1.027	1.048	1.017	0.017	0.011	0.008	0.010	0.018	0.020	0.018	0.015
	2	Y	1.009	1.020	1.022	1.015	1.008	1.031	1.058	1.023	0.015	0.010	0.011	0.012	0.016	0.015	0.030	0.015
	3	*N*	*1.011*	*1.021*	*1.023*	*1.019*	*1.006*	*1.031*	*1.055*	*1.024*	*0.013*	*0.014*	*0.012*	*0.011*	*0.013*	*0.013*	*0.043*	*0.017*
	4	*N*	*1.017*	*1.029*	*1.026*	*1.025*	*1.014*	*1.035*	*1.042*	*1.027*	*0.021*	*0.010*	*0.005*	*0.004*	*0.007*	*0.007*	*0.027*	*0.012*

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
11	0	N	0.971	0.960	0.964	0.965	0.957	0.956	0.964	0.963	0.016	0.016	0.019	0.018	0.021	0.025	0.035	0.021
	1	Y	0.962	0.957	0.961	0.958	0.961	0.954	0.979	0.962	0.026	0.016	0.017	0.017	0.020	0.023	0.039	0.022
	2	Y	0.960	0.957	0.963	0.964	0.963	0.959	0.980	0.964	0.018	0.019	0.020	0.020	0.022	0.028	0.048	0.025
	3	N	0.976	0.968	0.976	0.974	0.973	0.969	0.986	0.975	0.011	0.011	0.010	0.011	0.013	0.017	0.035	0.016
	4	N	0.976	0.967	0.975	0.969	0.975	0.961	0.980	0.972	0.022	0.007	0.007	0.013	0.011	0.026	0.041	0.018
13	0	N	0.957	0.963	0.966	0.972	0.963	0.976	0.952	0.964	0.013	0.010	0.012	0.009	0.012	0.015	0.020	0.013
	1	Y	0.958	0.962	0.966	0.971	0.968	0.966	0.957	0.964	0.019	0.010	0.013	0.011	0.011	0.014	0.031	0.016
	2	Y	0.960	0.961	0.964	0.968	0.964	0.973	0.956	0.964	0.022	0.013	0.015	0.013	0.013	0.016	0.029	0.017
	3	N	0.964	0.963	0.967	0.972	0.963	0.975	0.956	0.966	0.020	0.015	0.014	0.013	0.014	0.016	0.019	0.016
	4	N	0.961	0.962	0.965	0.974	0.968	0.969	0.950	0.964	0.012	0.012	0.015	0.012	0.013	0.019	0.030	0.016
15	0	N	0.995	0.992	0.994	1.000	0.990	1.004	0.999	0.996	0.009	0.006	0.006	0.005	0.008	0.012	0.019	0.009
	1	Y	0.992	0.988	0.990	0.994	0.997	1.001	1.009	0.996	0.012	0.008	0.009	0.010	0.013	0.014	0.017	0.012
	2	Y	0.995	0.992	0.995	1.001	0.997	1.006	1.010	1.000	0.013	0.008	0.006	0.007	0.007	0.007	0.021	0.010
	3	N	1.000	0.992	0.998	1.005	0.999	1.008	1.011	1.002	0.018	0.009	0.007	0.008	0.007	0.009	0.009	0.009
	4	N	0.995	0.989	0.993	1.002	0.997	1.006	1.004	0.998	0.009	0.007	0.006	0.010	0.009	0.013	0.026	0.011
16	0	N	0.972	0.975	0.976	0.980	0.973	0.976	0.942	0.970	0.028	0.011	0.016	0.013	0.015	0.022	0.031	0.019
	1	Y	0.981	0.977	0.972	0.981	0.984	0.989	0.939	0.975	0.023	0.014	0.018	0.019	0.021	0.023	0.027	0.021
	2	Y	0.978	0.973	0.972	0.985	0.984	1.005	0.962	0.980	0.031	0.013	0.017	0.016	0.015	0.024	0.034	0.022
	3	N	0.978	0.979	0.981	0.992	0.991	1.003	0.957	0.983	0.026	0.011	0.013	0.016	0.023	0.025	0.043	0.022
	4	N	0.983	0.975	0.983	0.991	0.996	1.013	0.972	0.987	0.034	0.015	0.014	0.016	0.014	0.016	0.030	0.020
28	0	N	1.007	0.987	1.013	0.979	1.015	1.023	1.021	1.007	0.034	0.042	0.035	0.032	0.027	0.015	0.046	0.033
	1	Y	0.998	0.985	1.001	0.966	1.019	1.020	1.029	1.003	0.032	0.042	0.025	0.050	0.016	0.012	0.021	0.028
	2	Y	1.007	0.988	1.014	0.979	1.022	1.031	1.027	1.010	0.024	0.048	0.016	0.026	0.015	0.025	0.038	0.028
	3	N	1.008	1.004	1.012	0.995	1.021	1.034	1.032	1.015	0.012	0.014	0.009	0.015	0.010	0.013	0.033	0.015
	4	N	1.013	1.003	1.012	0.987	1.027	1.032	1.040	1.016	0.011	0.013	0.017	0.029	0.011	0.015	0.030	0.018

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
30	0	N	0.986	0.998	0.979	0.992	0.986	0.991	1.058	0.999	0.016	0.028	0.017	0.008	0.013	0.019	0.039	0.020
	1	Y	0.990	0.998	0.981	0.990	0.994	0.976	1.040	0.995	0.023	0.034	0.013	0.020	0.018	0.021	0.044	0.025
	2	Y	0.992	1.003	0.994	0.992	0.995	0.980	1.029	0.998	0.014	0.017	0.006	0.011	0.016	0.016	0.031	0.016
	3	N	1.006	1.013	0.997	1.000	1.005	0.980	1.041	1.006	0.013	0.020	0.010	0.014	0.008	0.023	0.037	0.018
	4	N	0.999	1.019	0.996	1.003	1.000	0.992	1.026	1.005	0.014	0.024	0.013	0.012	0.010	0.019	0.030	0.017
	5	N	0.993	0.975	0.983	0.988	0.987	0.987	1.024	0.991	0.021	0.022	0.008	0.008	0.008	0.016	0.026	0.016
32	1	Y	1.023	1.051	1.036	1.034	1.033	1.020	0.985	1.026	0.026	0.010	0.015	0.021	0.032	0.051	0.066	0.031
	5	Y	1.020	1.038	1.026	1.025	1.023	1.021	0.987	1.020	0.017	0.022	0.019	0.025	0.035	0.050	0.088	0.037
33	0	N	1.024	1.037	1.032	1.035	1.042	1.030	1.018	1.031	0.014	0.013	0.021	0.012	0.015	0.018	0.050	0.020
	1	N	1.016	1.032	1.025	1.037	1.029	1.038	1.032	1.030	0.072	0.023	0.025	0.019	0.023	0.033	0.078	0.039
	2	Y	1.018	1.029	1.020	1.029	1.023	1.024	0.992	1.019	0.022	0.014	0.016	0.016	0.026	0.027	0.058	0.026
	3	Y	1.020	1.018	1.014	1.021	1.010	1.017	0.984	1.012	0.027	0.020	0.013	0.014	0.017	0.021	0.064	0.025
34	0	N	1.024	1.017	1.009	1.009	1.004	1.000	0.980	1.006	0.014	0.013	0.015	0.018	0.021	0.035	0.048	0.023
	1	Y	1.019	1.012	1.010	1.005	1.003	0.990	0.991	1.004	0.022	0.014	0.013	0.014	0.016	0.030	0.044	0.022
	2	Y	1.010	1.008	1.003	1.001	0.997	0.979	0.991	0.998	0.011	0.011	0.013	0.011	0.017	0.042	0.022	0.018
	3	N	1.017	1.012	1.011	1.008	1.002	0.989	1.014	1.007	0.017	0.010	0.013	0.012	0.019	0.032	0.040	0.021
	4	N	1.017	1.014	1.012	1.014	1.008	0.998	1.003	1.009	0.019	0.020	0.021	0.017	0.021	0.037	0.035	0.024
36	0	N	1.092	1.098	1.091	1.081	1.093	1.069	1.059	1.083	0.012	0.018	0.013	0.017	0.017	0.019	0.044	0.020
	1	N	1.087	1.102	1.093	1.078	1.092	1.060	1.064	1.082	0.013	0.012	0.010	0.012	0.018	0.016	0.047	0.018
	2	N	1.091	1.106	1.096	1.084	1.093	1.063	1.050	1.083	0.012	0.012	0.011	0.014	0.017	0.017	0.044	0.018
	3	Y	1.009	1.011	1.004	0.995	0.999	0.975	0.966	0.994	0.010	0.010	0.009	0.010	0.011	0.011	0.039	0.014
	4	Y	1.012	1.017	1.008	1.001	1.004	0.979	0.957	0.997	0.017	0.010	0.010	0.011	0.011	0.012	0.036	0.015
	5	N	1.025	1.023	1.015	1.002	1.009	0.988	0.971	1.005	0.010	0.010	0.007	0.007	0.010	0.011	0.027	0.012
37	0	N	1.035	1.024	1.024	1.030	1.021	1.023	1.021	1.025	0.019	0.025	0.026	0.033	0.033	0.045	0.060	0.034
	1	Y	1.029	1.015	1.014	1.016	1.020	1.011	0.999	1.015	0.018	0.025	0.023	0.022	0.022	0.031	0.061	0.029
	2	Y	1.030	1.012	1.015	1.018	1.016	1.014	1.000	1.015	0.025	0.027	0.027	0.031	0.030	0.038	0.059	0.034
	3	N	1.032	1.010	1.012	1.017	1.009	1.011	0.995	1.012	0.023	0.029	0.026	0.027	0.031	0.037	0.053	0.032
	4	N	1.032	1.009	1.008	1.015	1.013	1.009	0.991	1.011	0.022	0.031	0.028	0.030	0.031	0.042	0.055	0.034

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
38	*0*	*N*	*1.007*	*1.011*	*0.996*	*0.979*	*0.979*	*0.955*	*0.993*	*0.989*	*0.015*	*0.012*	*0.014*	*0.017*	*0.023*	*0.029*	*0.033*	*0.020*
	1	Y	1.015	1.006	0.990	0.969	0.974	0.940	0.980	0.982	0.014	0.011	0.006	0.011	0.016	0.023	0.023	0.015
	2	Y	1.018	1.014	1.000	0.980	0.977	0.945	0.997	0.990	0.017	0.012	0.018	0.021	0.032	0.039	0.041	0.026
	3	*N*	*1.021*	*1.016*	*1.004*	*0.983*	*0.972*	*0.945*	*0.990*	*0.990*	*0.018*	*0.009*	*0.016*	*0.019*	*0.027*	*0.040*	*0.043*	*0.025*
	4	*N*	*1.034*	*1.015*	*1.001*	*0.982*	*0.973*	*0.935*	*0.983*	*0.989*	*0.021*	*0.011*	*0.018*	*0.021*	*0.032*	*0.042*	*0.044*	*0.027*
39	*0*	*N*	*0.985*	*0.997*	*0.993*	*1.003*	*0.993*	*0.988*	*0.982*	*0.991*	*0.018*	*0.012*	*0.015*	*0.016*	*0.019*	*0.017*	*0.037*	*0.019*
	1	Y	0.999	1.005	0.996	0.999	0.995	0.985	0.980	0.994	0.017	0.010	0.010	0.011	0.011	0.011	0.022	0.013
	2	Y	0.993	1.003	0.997	1.002	1.000	0.987	0.984	0.995	0.012	0.008	0.007	0.007	0.007	0.008	0.016	0.009
	3	*N*	*0.996*	*1.004*	*1.001*	*1.008*	*0.999*	*0.993*	*0.987*	*0.998*	*0.015*	*0.011*	*0.011*	*0.011*	*0.011*	*0.013*	*0.025*	*0.014*
	4	*N*	*0.998*	*1.008*	*1.004*	*1.011*	*1.005*	*0.992*	*0.983*	*1.000*	*0.016*	*0.011*	*0.010*	*0.012*	*0.009*	*0.011*	*0.020*	*0.013*
	5	*N*	*0.988*	*0.992*	*0.992*	*1.001*	*0.995*	*0.997*	*0.997*	*0.994*	*0.010*	*0.006*	*0.010*	*0.009*	*0.014*	*0.013*	*0.022*	*0.012*
40	*0*	*N*	*1.031*	*1.025*	*1.021*	*1.038*	*1.016*	*1.017*	*1.007*	*1.022*	*0.013*	*0.010*	*0.014*	*0.016*	*0.010*	*0.018*	*0.027*	*0.015*
	1	Y	1.022	1.021	1.017	1.030	1.019	1.017	1.022	1.021	0.016	0.016	0.012	0.015	0.011	0.019	0.023	0.016
	2	Y	1.032	1.029	1.024	1.037	1.025	1.014	1.018	1.026	0.014	0.011	0.009	0.014	0.010	0.016	0.031	0.015
	3	*N*	*1.035*	*1.027*	*1.026*	*1.040*	*1.024*	*1.017*	*1.013*	*1.026*	*0.022*	*0.012*	*0.011*	*0.009*	*0.010*	*0.019*	*0.023*	*0.015*
	4	*N*	*1.039*	*1.033*	*1.029*	*1.040*	*1.020*	*1.016*	*1.013*	*1.027*	*0.020*	*0.017*	*0.016*	*0.020*	*0.018*	*0.020*	*0.040*	*0.022*
41	*0*	*N*	*0.989*	*1.001*	*1.002*	*1.002*	*0.998*	*1.008*	*0.984*	*0.998*	*0.012*	*0.014*	*0.014*	*0.015*	*0.014*	*0.021*	*0.035*	*0.018*
	1	Y	0.984	0.988	0.992	0.988	0.992	1.001	0.980	0.989	0.008	0.011	0.011	0.010	0.016	0.021	0.044	0.017
	2	Y	0.987	0.990	0.990	0.992	0.988	1.008	0.983	0.991	0.019	0.014	0.013	0.015	0.015	0.019	0.042	0.019
	3	*N*	*0.982*	*0.986*	*0.995*	*0.993*	*0.985*	*1.012*	*0.987*	*0.992*	*0.022*	*0.015*	*0.015*	*0.013*	*0.017*	*0.022*	*0.033*	*0.020*
	4	*N*	*0.991*	*0.992*	*0.997*	*1.000*	*0.995*	*1.016*	*0.995*	*0.998*	*0.022*	*0.013*	*0.013*	*0.010*	*0.011*	*0.021*	*0.036*	*0.018*
42	*1*	*N*	*Conducted partial lap so not included in analysis*								*Conducted partial lap so not included in analysis*							
	2	Y	0.977	0.992	1.005	1.003	1.002	1.008	1.008	0.999	0.054	0.019	0.019	0.018	0.019	0.022	0.034	0.026
	3	Y	0.973	0.979	0.992	0.993	0.989	0.999	0.993	0.988	0.026	0.016	0.018	0.017	0.025	0.018	0.028	0.021
	4	*N*	*0.964*	*0.975*	*0.989*	*0.991*	*0.992*	*1.000*	*0.977*	*0.984*	*0.027*	*0.014*	*0.017*	*0.016*	*0.021*	*0.020*	*0.015*	*0.019*
43	*0*	*N*	*1.006*	*0.941*	*1.040*	*1.033*	*0.990*	*1.020*	*0.891*	*0.989*	*0.044*	*0.044*	*0.041*	*0.059*	*0.090*	*0.083*	*0.172*	*0.076*
	1	Y	0.979	0.921	1.006	1.002	0.974	0.995	0.880	0.965	0.037	0.042	0.045	0.059	0.086	0.085	0.162	0.074
	2	Y	0.969	0.922	1.002	1.002	0.967	0.988	0.865	0.959	0.039	0.037	0.037	0.054	0.082	0.086	0.162	0.071
	3	*N*	*0.971*	*0.915*	*1.003*	*0.984*	*0.966*	*0.994*	*0.898*	*0.962*	*0.063*	*0.051*	*0.051*	*0.059*	*0.090*	*0.086*	*0.158*	*0.080*

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
44	*0*	*N*	*0.994*	*0.999*	*0.998*	*1.021*	*0.998*	*0.993*	*0.965*	*0.995*	*0.017*	*0.008*	*0.010*	*0.010*	*0.019*	*0.020*	*0.016*	*0.014*
	1	Y	0.977	0.984	0.981	1.001	0.983	0.978	0.970	0.982	0.018	0.015	0.015	0.020	0.023	0.018	0.031	0.020
	2	Y	0.975	0.984	0.985	1.006	0.997	0.983	0.966	0.985	0.019	0.019	0.018	0.022	0.032	0.022	0.025	0.022
	3	*N*	*0.986*	*0.988*	*0.991*	*1.016*	*0.990*	*0.986*	*0.968*	*0.989*	*0.012*	*0.011*	*0.007*	*0.016*	*0.010*	*0.020*	*0.026*	*0.015*
	4	*N*	*0.977*	*0.985*	*0.986*	*1.013*	*0.991*	*0.990*	*0.967*	*0.987*	*0.011*	*0.010*	*0.009*	*0.012*	*0.011*	*0.017*	*0.033*	*0.015*

Table F.2 2015 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	1	1.026	1.027	1.022	1.016	1.010	1.014	0.994	1.015	0.018	0.005	0.005	0.010	0.009	0.011	0.020	0.011	
	2	1.028	1.030	1.023	1.022	1.014	1.021	1.003	1.020	0.010	0.009	0.011	0.013	0.015	0.020	0.018	0.014	
8	4	0.953	0.962	0.967	0.977	0.996	1.010	1.044	0.987	0.022	0.018	0.020	0.023	0.035	0.049	0.069	0.034	
	5	0.949	0.959	0.971	0.975	0.996	1.023	1.047	0.988	0.021	0.012	0.019	0.028	0.031	0.049	0.065	0.032	
9	1	0.995	0.998	0.999	0.996	0.992	0.993	0.994	0.995	0.011	0.008	0.011	0.009	0.009	0.011	0.023	0.012	
	2	1.001	0.998	0.996	0.996	0.993	1.003	0.989	0.996	0.023	0.011	0.013	0.014	0.010	0.018	0.016	0.015	
10	1	1.004	1.017	1.014	1.007	0.999	1.027	1.048	1.017	0.017	0.011	0.008	0.010	0.018	0.020	0.018	0.015	
	2	1.009	1.020	1.022	1.015	1.008	1.031	1.058	1.023	0.015	0.010	0.011	0.012	0.016	0.015	0.030	0.015	
11	1	0.962	0.957	0.961	0.958	0.961	0.954	0.979	0.962	0.026	0.016	0.017	0.017	0.020	0.023	0.039	0.022	
	2	0.960	0.957	0.963	0.964	0.963	0.959	0.980	0.964	0.018	0.019	0.020	0.020	0.022	0.028	0.048	0.025	
13	1	0.958	0.962	0.966	0.971	0.968	0.966	0.957	0.964	0.019	0.010	0.013	0.011	0.011	0.014	0.031	0.016	
	2	0.960	0.961	0.964	0.968	0.964	0.973	0.956	0.964	0.022	0.013	0.015	0.013	0.013	0.016	0.029	0.017	
15	1	0.992	0.988	0.990	0.994	0.997	1.001	1.009	0.996	0.012	0.008	0.009	0.010	0.013	0.014	0.017	0.012	
	2	0.995	0.992	0.995	1.001	0.997	1.006	1.010	1.000	0.013	0.008	0.006	0.007	0.007	0.007	0.021	0.010	
16	1	0.981	0.977	0.972	0.981	0.984	0.989	0.939	0.975	0.023	0.014	0.018	0.019	0.021	0.023	0.027	0.021	
	2	0.978	0.973	0.972	0.985	0.984	1.005	0.962	0.980	0.031	0.013	0.017	0.016	0.015	0.024	0.034	0.022	
28	1	0.998	0.985	1.001	0.966	1.019	1.020	1.029	1.003	0.032	0.042	0.025	0.050	0.016	0.012	0.021	0.028	
	2	1.007	0.988	1.014	0.979	1.022	1.031	1.027	1.010	0.024	0.048	0.016	0.026	0.015	0.025	0.038	0.028	

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	
30	1	0.990	0.998	0.981	0.990	0.994	0.976	1.040	0.995	0.023	0.034	0.013	0.020	0.018	0.021	0.044	0.025	
	2	0.992	1.003	0.994	0.992	0.995	0.980	1.029	0.998	0.014	0.017	0.006	0.011	0.016	0.016	0.031	0.016	
32	1	1.023	1.051	1.036	1.034	1.033	1.020	0.985	1.026	0.026	0.010	0.015	0.021	0.032	0.051	0.066	0.031	
	5	1.020	1.038	1.026	1.025	1.023	1.021	0.999	1.022	0.017	0.022	0.019	0.025	0.035	0.050	0.075	0.035	D7 Station 5
33	2	1.018	1.029	1.020	1.029	1.023	1.024	0.992	1.019	0.022	0.014	0.016	0.016	0.026	0.027	0.058	0.026	
	3	1.020	1.018	1.014	1.021	1.010	1.017	0.984	1.012	0.027	0.020	0.013	0.014	0.017	0.021	0.064	0.025	
34	1	1.019	1.012	1.010	1.005	1.003	0.990	0.991	1.004	0.022	0.014	0.013	0.014	0.016	0.030	0.044	0.022	
	2	1.010	1.008	1.003	1.001	0.997	0.979	0.991	0.998	0.011	0.011	0.013	0.011	0.017	0.042	0.022	0.018	
36	3	1.009	1.011	1.004	0.995	0.999	0.975	0.966	0.994	0.010	0.010	0.009	0.010	0.011	0.011	0.039	0.014	
	4	1.012	1.017	1.008	1.001	1.004	0.979	0.957	0.997	0.017	0.010	0.010	0.011	0.011	0.012	0.036	0.015	
37	1	1.029	1.015	1.014	1.016	1.020	1.011	0.999	1.015	0.018	0.025	0.023	0.022	0.022	0.031	0.061	0.029	
	2	1.030	1.012	1.015	1.018	1.016	1.014	1.000	1.015	0.025	0.027	0.027	0.031	0.030	0.038	0.059	0.034	
38	1	1.015	1.006	0.990	0.969	0.974	0.940	0.980	0.982	0.014	0.011	0.006	0.011	0.016	0.023	0.023	0.015	
	2	1.018	1.014	1.000	0.980	0.977	0.945	0.997	0.990	0.017	0.012	0.018	0.021	0.032	0.039	0.041	0.026	
39	1	0.999	1.005	0.996	0.999	0.995	0.985	0.980	0.994	0.017	0.010	0.010	0.011	0.011	0.011	0.022	0.013	
	2	0.993	1.003	0.997	1.002	1.000	0.987	0.984	0.995	0.012	0.008	0.007	0.007	0.007	0.008	0.016	0.009	
40	1	1.022	1.021	1.017	1.030	1.019	1.017	1.022	1.021	0.016	0.016	0.012	0.015	0.011	0.019	0.023	0.016	
	2	1.032	1.029	1.024	1.037	1.025	1.014	1.018	1.026	0.014	0.011	0.009	0.014	0.010	0.016	0.031	0.015	
41	1	0.984	0.988	0.992	0.988	0.992	1.001	0.980	0.989	0.008	0.011	0.011	0.010	0.016	0.021	0.044	0.017	
	2	0.987	0.990	0.990	0.992	0.988	1.008	0.983	0.991	0.019	0.014	0.013	0.015	0.015	0.019	0.042	0.019	
42	2	0.977	0.992	1.005	1.003	1.002	1.008	1.008	0.999	0.054	0.019	0.019	0.018	0.019	0.022	0.034	0.026	
	3	0.973	0.979	0.992	0.993	0.989	0.999	0.993	0.988	0.026	0.016	0.018	0.017	0.025	0.018	0.028	0.021	
43	1	0.979	0.921	1.006	1.002	0.974	0.995	0.897	0.968	0.037	0.042	0.045	0.059	0.086	0.085	0.142	0.071	D7 station 5
	2	0.969	0.922	1.002	1.002	0.967	0.988	0.883	0.962	0.039	0.037	0.037	0.054	0.082	0.086	0.139	0.068	D7 station 5
44	1	0.977	0.984	0.981	1.001	0.983	0.978	0.970	0.982	0.018	0.015	0.015	0.020	0.023	0.018	0.031	0.020	
	2	0.975	0.984	0.985	1.006	0.997	0.983	0.966	0.985	0.019	0.019	0.018	0.022	0.032	0.022	0.025	0.022	

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	High	No data
8	Dynatest FWD 8002 SN 028	Pass	Pass	Pass	Pass	Pass	High	High	High	High	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	High	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	High	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	High	No data
30	Dynatest 8002 FWD SN 173	Pass	Pass	Pass	Pass	Pass	High	High	High	High	Low
32	Dynatest HWD 8082 SN 069	Pass	Pass	Pass	Fail	Fail	Not tested			Low	No data
33	Dynatest HWD 8082 SN 070	Pass	Pass	Pass	Pass	Fail	High	High	High	High	Invalid data
34	Dynatest HWD 8082 SN 108	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data
36	Grontmij FWD PRI2500 SN 0608-303	Pass	Pass	Pass	Pass	Pass	High	High	High	High	Low
37	Dynatest FWD 8002 SN 352	Pass	Pass	Pass	Pass	Pass	High	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
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	Fail	High	High	High	High	No data
43	PaveTesting FWD SA9FF1324FE258074	Pass	Fail	Fail	Fail	Fail	Not tested			High	No data
44	Dynatest HWD 8082 SN 156	Pass	Pass	Pass	Pass	Pass	High	High	High	High	No data

Appendix H 2015 DPT trial – Contact details and summary outcome

Table H.1 2015 trial contact details and summary outcome

TRL Ref. no.	Owning Company	Make, model and serial number	Contact details	Recommend for use on HE network
5	AECOM /URS Ltd.	Dynatest HWD 8082 SN 050	John Dobrzycki, URS, 12 Regan Way, Chetwynd Business Park, Chilwell, Nottingham NG9 6RZ	Yes
8	AECOM /URS Ltd.	Dynatest FWD 8002 SN 028	As Machine 5	Yes
9	PMS Ltd.	Dynatest 8002 FWD SN 136	Eoin Greaney, PMS Pavement Management Services Ltd, Raheen Industrial Estate, Athenry, Co. Galway, Ireland	Yes
10	AECOM /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	AECOM /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 9	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	**No**
33	ALC (MoD)	Dynatest HWD 8082 SN 070	As Machine 32	**No**
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	**No**
43	PaveTesting	PaveTesting FWD SA9FF1324FE258074	PaveTesting, Unit 2, Iceni Court, Letchworth Garden City	**No**
44	Dynatest UK Ltd	Dynatest HWD 8082 SN 156	As Machine 40	Yes

Highways England 2015 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 2015 trial run by TRL and held on the Horiba-MIRA proving ground between 29th and 30th September 2015.

Other titles from this subject area

PPR 947	Highways Agency 2014 National Dynamic Plate Test device Accreditation Trial. S Brittain. 2020
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

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