Accreditation and Quality Assurance of Dynamic Plate Test Survey Devices

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Contents Amendment Record

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Contents

Definitions of terms used in this document

This document uses a selection of specific terms which are either defined below or are detailed in the corresponding standard for the surveys of these devices on UK trunk roads, HD29 (Volume 7 Section 3 part 2 of the Design Manual for Roads and Bridges).

Accreditation Certificate; documentary evidence of the performance achieved during an Accreditation/Re-accreditation Trial. It will contain the limitations and validity period of the accreditation. It should be retained by the Owner and produced upon request.

Accreditation Period; normally 13 months from the date of attending an Accreditation/Re-accreditation Trial.

Accredited Surveys; surveys undertaken using Equipment which is adhering to the required QA and has a valid Accreditation Certificate.

Accreditation Trial; an event where accreditation tests are performed to demonstrate that the Equipment can meet the specification requirements under rigorously controlled test conditions (also see Re-accreditation Trial).

Auditor; any organisation overseeing the Accreditation and QA programmes outlined in this specification. Specific requirements imposed on the Auditor are given in Appendix B. The Auditor is determined by the Employer or the Network Authority.

Calibration; laboratory (or baseline) calibration of a System (or one of its Components) of the Equipment.

Component; refers to a part of one of the Systems fitted to the Equipment.

Contractor; the organisation carrying out the Accredited Survey. The Contractor can be the Owner of the Equipment.

Contractor's Calibration Check; QA assessment undertaken by the Contractor to determine if the Equipment is performing to an acceptable level of consistency between Accreditation/Re-accreditation Trials.

Contractor's Calibration Site; a site where Regular Checks to monitor the long term performance of the Equipment are undertaken.

Contractor's Quality Assurance; Quality Assurance by the supplier of the product or service, in this case, the Contractor.

Developer; the manufacturer of an existing Equipment or System, or the organisation or individual who is introducing a new model or variant of Equipment or System.

Employer; the organisation that commissions the Contractor to provide Survey Data. This may be the Network Authority.

Equipment; the overall machine carrying out the survey, incorporating the measuring systems and where applicable the survey vehicle.

Fleet; collection of Equipment which provides the Reference Data for an Accreditation/Re-accreditation Trial.

Improvement Notice; a notice issued to the Owner and/or Contractor if the Auditor finds the Equipment is not meeting the requirements of the Accreditation or Quality Assurance process. The notice will detail the timescale within which the improvement is required and any restrictions to the use of the equipment prior to satisfactory completion of the improvement.

Lay Off Period; a period of time greater than 10 working days where the Equipment is not surveying (for the purposes of this specification it also means a period when surveying for Employers who do not require adherence to this standard).

Location Referencing; the techniques and conventions that are used to locate items on the road Network.

Network; roads in a given area or of a given classification for which the Network Authority has responsibility.

Network Authority; the organisation ultimately responsible for maintenance of any given road network, such as Highways England or a Local Highway Authority.

Owner; the organisation or individual to whom the Equipment belongs and to whom Accreditation Certificates are awarded.

Parameter; specific data fields that form part of the Survey Data supplied by the Contractor to the Employer. This includes temperature and deflection.

Primary Check Site; a site established by the Contractor to check medium term consistency of the Survey Data.

Quality Assurance (QA); a process to give the Employer confidence that the data and results being provided are reliable, consistent and suitable for purpose.

Reference Data; data against which the Equipment will be compared for the purposes of Accreditation or Quality Assurance.

Re-accreditation Trial; an event where performance tests are carried out on Equipment which has previously met the mandatory requirements of an Accreditation Trial.

Routine Maintenance; any maintenance or work done on the Equipment which may affect, or there is a risk that it may affect, the measurement performance (for example accuracy, reliability, consistency) of the Equipment.

Survey Data; data collected by the Contractor using the Equipment and supplied to the Employer.

System; individual measurement system installed on the Equipment e.g. Distance measurement system, Ordinance Survey Grid Reference (OSGR) measurement system.

Section A Introduction

A.1 Introduction

A1.1 It is essential that maintenance of a road network is planned, prioritised and undertaken in a way that limits delays when carrying out roadworks and improvements. It should provide value for money and investment in improved service which helps to make journeys safer and more reliable. A key element in the successful maintenance of a network is the accurate, reliable and consistent assessment of the pavement's surface and structural condition. Inaccurate condition assessment data could, on one hand, lead to unnecessary and costly works causing needless traffic congestion. On the other hand, if maintenance is overlooked, it could lead to poorly maintained carriageways presenting a risk to road users.

A1.2 Within the Standard for UK trunk roads, HD29 (Volume 7 Section 3 part 2 of the Design Manual for Roads and Bridges), it is required that Contractors commissioned to supply Survey Data use Equipment that has been accredited to undertake these surveys and the data provided must be checked using a suitable Quality Assurance process.

A1.3 An Accreditation and Quality Assurance programme has therefore been devised for Dynamic Plate Test (DPT) devices. This process is the subject of this document.

A1.4 The central principles of the Accreditation and Quality Assurance programme are:

- To undertake tests of the Equipment leading to the award of an Accreditation Certificate showing suitable performance levels prior to undertaking Accredited Surveys.
- To undertake Re-accreditation at appropriate intervals.
- To apply an on-going Quality Assurance programme for all Accredited Surveys.
- To confirm that the Accreditation and Quality Assurance programme is implemented, via independent audit.

A1.5 This specification applies to category B to D DPT devices (see C2.3 for further information) mounted on vehicles or trailers. These devices are also commonly known as "Static Plate Impact Deflectometers" or "Falling Weight Deflectometers".

A1.6 This document sets out the requirements for Accreditation, Re-accreditation and Quality Assurance of DPT surveys carried out to characterise road condition under HD29.

A.2 Summary of the Accreditation and QA process

A2.1 Prior to the Accreditation and QA process it is necessary to identify an Auditor or Auditors to oversee the process. The Employer will nominate an Auditor and/or may conduct some or all of the Auditor's role internally. Further details on the responsibilities of these roles are given in Section B.

A2.2 The overall DPT Accreditation and QA process is shown in Figure 1, and is described further in the following sub-sections.

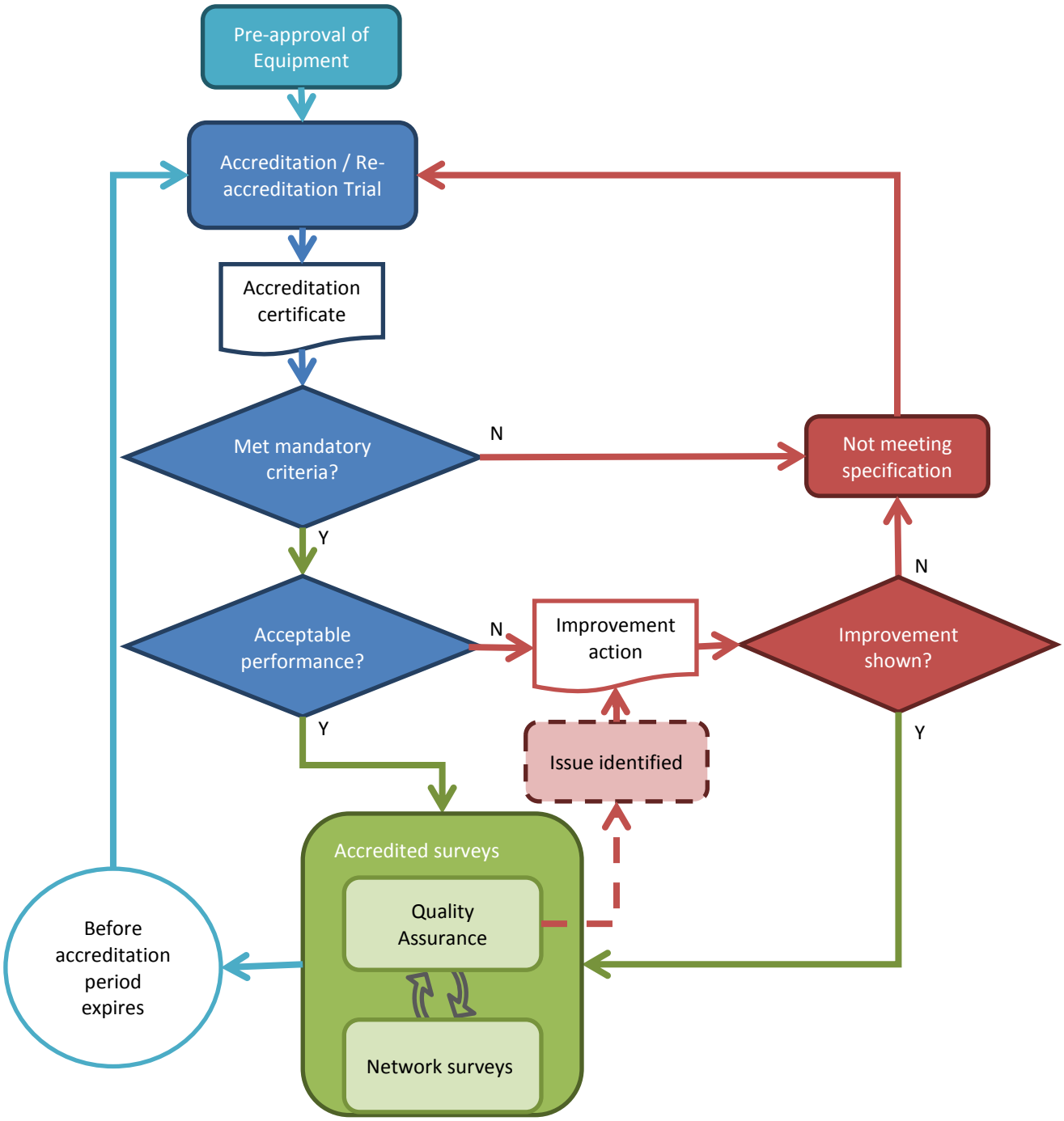

Figure 1 - The Accreditation and QA process

A2.3 Pre-approval of Equipment

A2.3.1 Prior to undertaking an Accreditation/Re-accreditation Trial, it may be necessary to undertake an assessment of the Equipment to check its suitability for undertaking Accredited Surveys. The need for this will be determined by the Auditor.

A2.4 Accreditation/Re-accreditation Trial

A2.4.1 Any machines seeking to undertake Accredited Surveys must take part in, and provide satisfactory performance in, an Accreditation/Re-accreditation Trial.

A2.4.2 Following completion of a Trial the Auditor will issue an Accreditation Certificate. The Certificate will detail the level of performance achieved by the Equipment at the Trial.

A2.4.3 If the Equipment has not met the mandatory requirements of the trial then this Equipment is not meeting specification, and will need to undertake an additional Trial and meet the requirements before undertaking Accredited Surveys.

A2.4.4 If the Equipment has met the mandatory requirements of the trial, but has poor performance in non-mandatory aspects, then the Auditor may issue an Improvement Notice in addition to the Accreditation Certificate. If the required improvement is not demonstrated to the Auditor in the time specified in the Improvement Notice then the Equipment may no longer be considered Accredited.

A2.5 Accredited Surveys

A2.5.1 Accredited Surveys, are network surveys undertaken by Accredited Equipment, combined with Quality Assurance (QA).

A2.5.2 If the QA or other process identifies an issue that may affect Survey Data the Auditor may issue an Improvement Notice to the Contractor and supply a copy to the Employer. If a suitable improvement is not demonstrated to the Auditor in the given time frame then the Equipment accreditation status may be revoked.

A2.6 Accreditation Period

A2.6.1 Each Accreditation Certificate issued by the Auditor will have a corresponding Accreditation Period. Owners/Contractors wishing to continue to undertake Accredited Surveys must attend a Re-accreditation Trial prior to the end of the Accreditation period.

A.3 Structure of this document

A3.1 This document is split into several sections:

- The roles and responsibilities of the involved parties are given in Section B
- The specification for the DPT device is provided in Section C.
- The Accreditation trials (undertaken on any new survey equipment) are detailed in Section D.
- The Re-accreditation trials (undertaken on equipment that has been previously Accredited) are detailed in Section E.
- The Contractor's Quality Assurance procedures, are detailed in Section F.
- The Quality Assurance checks conducted by the Auditor are described in Section G.
- Details on Improvement Notices which may be issued by the Auditor are given in Section H.

Section B Roles of the relevant parties

B.1 Employer

B1.1 The Employer should consider the requirements for Accreditation and QA ahead of appointing a survey contractor to undertake DPT surveys:

- The Employer should require (for example within any contract or order) that the Contractor has achieved Accreditation for their Equipment. Employers should request the Contractor to provide a copy of an Accreditation Certificate (or Certificates) that is valid throughout the period over which surveys are to be carried out on the Employer's Network.
- The Employer should require that the Contractor undertakes QA checks. These QA checks will be as specified in this document unless replaced by alternative or additional checks defined by the Employer.

B1.2 To ensure that the required Accreditation and QA processes are applied, the Employer should nominate an Auditor to carry out checks. The Employer may choose to conduct some or all of the Auditor's role internally. If the Employer chooses to act as (or appoint an) Auditor they should ensure that the relevant personnel hold the required skills to undertake these checks and understand the results (see Appendix B).

B.2 Owner

B2.1 Owners should ensure that their Equipment is compliant with the equipment configuration and specification given in Section C.

B2.2 Owners should obtain Accreditation via an Accreditation/Re-accreditation trial prior to undertaking Accredited Surveys. This will be achieved by commissioning an Auditor to carry out an Accreditation trial. An Owner may commission an Accreditation Trial at any time. However some Network Authorities may provide centrally organised annual Accreditation Trials. The process and requirements of these trials are given in Section D and Section E.

B2.3 Owners must renew the Accreditation status of their Equipment by the end of the Accreditation Period if they wish to continue to undertake Accredited Surveys.

B2.4 It is desirable that the Owner should have their own ISO 9001 process and continue to undertake checks to support this. However the Owner must also ensure that they adhere to all QA requirements specified in this document or otherwise specified by the Employer.

B2.5 Where Equipment is hired by the Owner to a Contractor, the Owner should ensure that the Contractor takes responsibility for conducting the required QA during the period of hire.

B2.6 The Owner must report promptly to the Auditor any Routine Maintenance or alterations carried out on the Equipment that could affect the measurement of Survey Data.

B.3 Contractor

B3.1 A Contractor hiring Equipment must establish, from the Owner and/or the Employer (as appropriate), the Accreditation status of the Equipment and the QA requirements of the Employer.

B3.2 The Contractor must ensure that the Equipment completes the QA required by their Employer(s). In addition the Owner may require the Contractor to undergo QA to maintain Accredited status throughout the period of hire. For example ensuring regular checks are carried out as scheduled when equipment is transferred from one Contractor to another.

B3.3 The Contractor shall ensure that the Equipment shall only be driven and operated by competent drivers and operatives. The Contractor is responsible for the training and instruction of all drivers and operatives and for ensuring that they comply with the requirements for surveys.

B.4 Auditor

B4.1 The key roles of the Auditor are to carry out Accreditation and Re-accreditation Trials and to carry out QA checks. These roles may be carried out by the same or by separate bodies. In the main body of this document the role is simply referred to as "the Auditor". Specific requirements for the bodies undertaking one or both of these roles are given in Appendix B.

B4.2 If the Auditor identifies an issue with the Equipment, QA or survey process which could affect the quality of the Survey Data the Auditor may issue an Improvement Notice to the Contractor/Owner. Copies of these improvement notices will also be supplied to the Employer.

Section C Equipment

C.1 Introduction

C1.1 The specification for measurement of pavement strength using a DPT device is given in Volume 7 Section 3 Part 2 of the Design Manual for Roads and Bridges (DMRB); HD29 Data for pavement assessment. The general description, Equipment classification and additional components are described in this Section.

C.2 General description and equipment classification

C2.1 DPT Equipment can either be hand held machines, or devices built into existing vehicles, or devices mounted on a trailer and towed behind a vehicle. Each Equipment incorporates a circular loading plate that is lowered onto the pavement surface when testing. The Equipment then lifts a known load to a predetermined height and drops it onto the plate creating an impact load. A set of buffers or a system of springs located between the plate and the falling weight are used to spread the impact and produce a particular load pulse shape from the impact.

C2.2 The Equipment is equipped with a load cell which measures the peak impact load applied to the plate. The vertical deflections produced by the impact are measured both at the centre of the plate and at a series of radial positions from the centre. The measured deflections at these radial positions are a function of the applied load and may be used to determine the structural strength of the pavement under test.

C2.3 Most DPT Equipment is classified by the load that can be applied to the test plate. There are four main categories, A to D:

A. Lightweight Equipment can apply a test load in the range of 1-15kN
B. Medium weight Equipment which can apply a test load in the range of 30 to 120kN
C. Heavyweight Equipment that can apply a test load in the range 30 to 240kN
D. Super Heavy weight Equipment that can a test load in the range 30 to 300kN

C2.4 This specification has been written for DPT Equipment that undertake testing where loads of between 30kN and 120kN can be applied (i.e. Categories B, C and D).

C2.5 For guidance, some Equipment from Categories B, C and D that have previously met these requirements are listed in App A.2. New Equipment models (outside this list) or heavily modified existing Equipment from this list may need an inspection by the Auditor prior to being allowed to attend accreditation testing to ensure that they are eligible for accreditation. The Auditor may charge a supplementary fee for this additional inspection.

C2.6 DPT Equipment covered in this specification must be fitted with a Distance Measurement Instrument (DMI) or odometer. The DMI will measure the position of test stations in terms of elapsed distance (chainage) from a fixed reference point.

C2.7 Equipment covered in this specification must include a calibrated thermometer or suitable probe for pavement temperature measurement as defined in HD29.

C2.8 Further detail on the Equipment covered in this specification is given in App A.1.

C.3 Additional components

C3.1 The Equipment may also be fitted with a spatial referencing System, usually based on the Global Positioning System (GPS) method or equivalent.

C.4 Calibration of the Equipment

C4.1 Sections D, E, and F of this document describe the Accreditation and QA processes to be applied to test and monitor the performance of the Equipment. The tests assume that any day to day or longer term calibration required to ensure the ongoing performance of the equipment has been carried out by the Contractor, Equipment Developer or System Developer as appropriate. Particular Systems or Components of the Equipment which are known to require Calibration include:

- Load cell calibration – reference calibration may be performed by the Equipment Developer, System Developer or by a recognised calibration laboratory.

- Deflection sensor calibration - reference calibration may be performed by the Equipment Developer, System Developer or by a recognised calibration laboratory.
- Odometer calibration – reference calibration may be performed by the Contractor.
- Temperature probe – reference calibration by probe manufacturer or by a recognised calibration laboratory.

Section D Accreditation

D.1 Introduction

D1.1 The purpose of an Accreditation Trial is to ensure that the Equipment is capable of measuring and reporting the Survey Data consistently under controlled conditions. It should also demonstrate that the Contractor is able to operate the Equipment in order to produce consistent and reliable Survey Data. The results from the Accreditation Trial should also show that all accredited Equipment are consistent within defined tolerances.

D1.2 Equipment will require Accreditation if one or more of the following conditions are met:

- The Equipment is new, or has not previously been Accredited to this specification or an earlier version of this specification.
- Equipment accredited to the specification has changed ownership and the new owner does not currently operate any Equipment accredited to this specification.
- Equipment previously accredited has lapsed in its accreditation status.

D.2 Accreditation

D2.1 Following completion of an Accreditation Trial the Auditor will issue Accreditation Certificates showing the performance achieved by the Equipment. The Certificate will expire 13 months from the Trial date.

D2.2 If the Equipment has met the mandatory criteria of the Accreditation Trial, but performance of the Equipment is not suitable in other aspects, then the Auditor will also issue an Improvement Notice as detailed in Section H.

D2.3 Once the Equipment has been accredited it will require Re-accreditation before the expiry of the Accreditation Period. This can be obtained by successfully completing a Re-accreditation Trial.

D.3 The Accreditation Trial

D3.1 Prior to an Accreditation Trial, pre-approval of any Equipment meeting the criteria in D1.2 is required. The Owner should provide details of their Equipment to the Auditor so that the Auditor can confirm it is eligible to attend the trial based on the specification given in Section C and can detail any additional assessments that will be required. The Auditor may charge a supplementary fee for these additional assessments.

D3.2 Following the successful completion of the pre-approval stage the Auditor will authorise the Equipment to take part in an Accreditation trial.

D3.3 The structure, criteria and requirements for an Accreditation Trial are exactly the same as those used for a Re-accreditation Trial. Therefore reference should be made to Section E for details of the trial, including criteria and requirements.

D3.4 The main difference between an Accreditation Trial and a Re-accreditation Trial is that any Equipment undertaking an Accreditation Trial cannot be included in the Reference Data.

D3.5 Note that, as well as testing the Equipment, the Auditor may assess and provide feedback on the competence of drivers and operatives as part of the Accreditation Trial.

Section E Re-accreditation

E.1 Introduction

E1.1 Re-accreditation Trials will typically include:

- Equipment inspections, which comprise overall checks of the Equipment and its Systems.
- Trials and assessment of Equipment against mandatory criteria.
- Trials and assessment of Equipment against additional criteria.

E1.2 Requirements for the test site and the required Reference Data for a Re-accreditation Trial are given in Appendix C.

E.2 Re-accreditation

E2.1 Following completion of a Re-accreditation Trial the Auditor will issue Accreditation Certificates showing the performance achieved by the Equipment. The Certificate will expire 13 months from the Trial date.

E2.2 If the Equipment has met the mandatory criteria of the Re-accreditation Trial, but the performance of the Equipment is not suitable in other aspects then the Auditor will also issue an Improvement Notice, as detailed in Section H

E2.3 Once the Equipment has been accredited it will require Re-accreditation before expiry of the Accreditation Period. This can be obtained by successfully completing another Re-accreditation Trial.

E.3 Equipment inspection

E3.1 Equipment will be inspected to ensure that they are in a suitable condition to conduct the tests. For nationally arranged accreditation trials Contractors will be provided with an inspection check sheet to complete and provide to the Auditor *in advance* of the Trial.

E3.2 Inspections will include:

- checking the Equipment is set in the correct configuration
- checking that a Contractor's pre-test inspection report has been provided and correctly filled in;
- verifying that the required Calibrations have been performed (see section C.4) and that the calibration factors provided on the latest calibration report/certificate match those entered into the Equipment;
- checking the temperature probes; and
- Verifying that the Equipment is in good general mechanical order.

E.4 Running Trials

E4.1 Overview

E4.1.1 As detailed in in Appendix C, trials will be carried out on a test site separated into test stations, and may be laid out such that laps of the set of test sections can be undertaken by the Fleet for the purposes of repeating the measurements.

E4.1.2 Testing will be conducted using a defined set of deflection sensor spacings typical of DPT surveys on the network. If sensors are fitted to the test Equipment at spacings other than those specified by the Auditor then the data from these will not be assessed as part of the Trial.

E4.2 Repeatability testing – Mandatory Requirement

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

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

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

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

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

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

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

Table 1 – Deflection Repeatability Criteria

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

E4.3 Reproducibility testing – Mandatory Requirement

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

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

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

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

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

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

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

Table 2 - Deflection Reproducibility Criteria

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

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

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

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

Table 3 - Acceptance Criteria for Location Reference Measurement

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

E.5 Additional Tests

E5.1 Overview

E5.1.1 During the course of the running trials, additional tests will be conducted on the assessment of location referencing and temperature measurement, as appropriate to the systems installed on the device under test.

E5.1.2 The criteria in this sub-section are additional criteria which are assessed to provide additional information on the capabilities of the Equipment. These criteria are assessed as High, Medium and Low levels of performance. These criteria typically include the assessment of Systems not fitted to all Equipment and/or tests which are not as mature as the mandatory assessments. In future revisions to this document some or all of these criteria may become mandatory criteria.

E5.1.3 Some Employers may require a specific level of performance in some or all of these additional tests to carry out Accredited Surveys on their Network.

E5.2 Location reference – OSGR coordinates

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

Table 4 - Acceptance Criteria for OSGR data

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

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

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

Table 5 - Acceptance Criteria for temperature measurement at depth

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

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

E5.4 Temperature measurement – temperature sensor for surface measurement

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

Table 6 - Acceptance Criteria for temperature measurement of pavement surface

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

Section F Contractor's Quality Assurance

F.1 Introduction

F1.1 An on-going Quality Assurance regime shall be applied to ensure that the data provided by the Equipment remains valid throughout the Accreditation Period. In addition to the specific processes described below, the Contractor's effective and documented Quality Assurance regime should cover all aspects of the surveys including, but not limited to:

- Equipment operation and maintenance
- Calibration of the Equipment
- Driver and operator training and instruction –the Equipment should only be driven and operated by competent personnel
- Survey operation and record keeping
- Data recording, processing, and analysis
- Delivery of Survey Data

F.2 Summary of the processes

F2.1 The following QA tests are required:

- Stack/tower Consistency Check (or Developer equivalent procedure) every six months.
- Contractor's Calibration Check within the defined time frame of the Accreditation/Re-accreditation Trial
- Contractor's Calibration Check at the end of a Lay Off period prior to conducting surveys
- Contractor's Calibration Check no more than 40 days apart whilst not in a Lay Off Period
- Two Weekly Check (no more than 20 days apart) whilst not in a Lay Off Period
- Contractor's Calibration Check before entering a Lay Off Period
- Daily Check every day testing is carried out

F2.2 It is also expected that the Contractor would check that any other Systems/Components are working satisfactorily between annual calibrations (e.g. temperature measurement System could be checked by measuring in an ice bucket and/or boiling water or by comparing against suitable reference(s)).

F.3 The Contractor's Calibration site and Primary Check site(s)

F3.1 It will be necessary for the Contractor to establish a number of fixed test sites to achieve the QA test programme. This will include a Contractor's Calibration site, and may optionally include Primary Check Site(s). The sites chosen by the Contractor should be reported to the Auditor. The sites may be subject to monitoring by the Auditor (using Independent Equipment) at any time.

F3.2 If the condition of a test site is affected by maintenance or other external factors at any time, the Contractor should notify the Auditor. The Contractor may be required to establish the changed characteristics of the site by repeated testing, or to establish another site as agreed with the Auditor.

F3.3 The Contractor should consult the local highway authority responsible for the test site location and obtain its agreement before making any marking on or modification of the site.

F3.3.1 A summary of the requirements for the sites required for QA is given in Appendix E.

F3.4 Contractor's Calibration site

F3.4.1 The Contractor's Calibration site provides a reference site for monitoring the performance of the Equipment since the last successful Accreditation or Re-accreditation of the Equipment.

F3.4.2 Typically the Contractor's Calibration site would be a single site close to the Contractor's base where measurements can be taken safely and without unreasonable disruption to other users of the site. The site should contain:

- At least two different construction types, at least one of which must be fully flexible pavement.
- At least 6 test points
- A length of at least 400m of straight and level pavement for the assessment and calibration of distance measurements.

F3.4.3 It may be necessary to form the Contractor's Calibration site from 2 or more locations to meet these requirements.

F3.4.4 To obtain deflection Reference data for the site, a reference survey should be carried out on the site with the Equipment within 7 days of successfully carrying out an Accreditation/Re-accreditation Trial.

F3.4.5 Locational reference data should be obtained on the site in the form of the length measured to an accuracy of ±0.5m, using steel tape or other reliable device. The OSGR co-ordinates of the test stations should also be accurately recorded if an OSGR System is fitted to the Equipment.

F3.4.6 The test site Reference Data should include all of the Survey Data and derived Parameters required for the corresponding QA test (see Table 7).

F3.4.7 The Survey Data obtained from the reference survey will constitute the test site Reference Data. The Contractor should build up a "historical data set" which can include data collected in the current and previous years whilst conducting Accredited Surveys.

F3.4.8 The Contractor may carry out more than one survey at the test site when collecting the Reference Data as a measure of consistency and repeatability.

F3.4.9 In some cases it may be necessary or desirable to establish a new Contractor's Calibration Site. This must be done by collecting Reference Data for the new site within a maximum of 7 days of a successful completion of a Check on the existing site but ideally on the same day.

F3.5 Primary Check site(s)

F3.5.1 The aim of the Primary Check sites is to provide an additional controlled reference site(s) for the Two Weekly check.

F3.5.2 The Primary Check site should be a site where measurements can be taken safely and without unreasonable disruption to other users of the site. The site should contain:

- At least one section of fully flexible pavement
- At least 6 test points.
- A length of at least 400m of straight and level pavement for the assessment of distance measurements.

F3.5.3 For operational convenience the Contractor may, if it desired, set up a number of Primary Check sites. These can be established throughout the year and at different geographical locations within the UK.

F3.5.4 To obtain deflection Reference Data for the site, a reference survey should be carried out on the site with the Equipment within 7 days of a successful survey of the Contractor's calibration site.

F3.5.5 Location reference data should be obtained on the site in the form of the length measured between known points. This can be obtained using the distance measurement System on the Equipment during the reference survey.

F3.5.6 The test site Reference Data should include all of the Survey Data and derived Parameters required for the corresponding QA test (see Table 7).

F3.5.7 The Survey Data obtained from the reference survey will constitute the test site Reference Data. The Contractor should build up a "historical data set" which can include data collected in the current and previous years whilst conducting Accredited Surveys.

F3.5.8 The Contractor may carry out more than one survey at the test site when collecting the Reference Data as a measure of consistency and repeatability.

F.4 Stack/Tower Consistency Check

F4.1 Overview

F4.1.1 The aim of the Stack/ Tower Consistency Check is to ensure that all deflection sensors are correctly calibrated relative to each other. It is not an absolute calibration check but should ensure consistency across all deflection sensors. On some Equipment this is commonly achieved by removing all deflection sensors from the Equipment and placing them in a collinear holder. The holder is placed on the pavement close to the loading plate and a test drop is performed. All deflection sensors should measure the same value (within prescribed tolerances).

F4.1.2 If the Equipment cannot undertake a Stack/Tower Consistency check then the Contractor must undertake a similar test which obtains the same goal. The details of this test must be communicated with the Auditor.

F4.1.3 The Stack/Tower Consistency Check (or equivalent) must be carried out no more than six months apart.

F4.2 Test process

F4.2.1 Since performing this test may require significant disassembly of the Equipment, a Contractor's Calibration Check must be performed immediately prior to and immediately following a Stack/Tower Consistency Check to ensure the components have been replaced correctly.

F4.2.2 If the tolerance levels as indicated by the calibration software are exceeded the Contractor may fine tune individual sensors to bring them into correct relative calibration. If large adjustments are required, faulty sensors should be replaced or repaired. The test should then be repeated.

F4.3 Reporting

F4.3.1 In the event of non-compliance of this check or the subsequent Contractor's Calibration Check, the Auditor shall be immediately informed. No further Surveys should be carried out by this Equipment until a resolution of the issue has been successfully demonstrated to the Auditor.

F4.3.2 Any surveys undertaken with the system considered to be "out of calibration" will be considered suspect and subject to further Auditor investigations.

F4.3.3 The records of the Stack/Tower Consistency Check (or equivalent) shall be maintained by the Contractor for examination by the Auditor if required. Any Stack/Tower Consistency Check records requested should be provided to the Auditor within 14 days

F.5 Contractor's Calibration Check

F5.1 Overview

F5.1.1 The aim of the Contractor's Calibration Check is to provide long term monitoring of the Equipment and to check the performance of the Equipment since the last Accreditation/Re-accreditation trial. The Contractor's Calibration Check may also incorporate the calibration of the location referencing System if required.

F5.1.2 During the Period of Work Contractor's Calibration Checks must be carried out no more than 40 days apart. The carrying out of a Contractor's Calibration Check satisfies the requirement for dynamic calibration specified in HD29. The site used for this check must be the Contractor's Calibration Site

F5.1.3 As part of the Contractor's Calibration Check, the Contractor should also carry out a visual inspection of the Equipment for any obvious mechanical defects and that the Equipment and all of its Systems are operating correctly. The checks should ensure the Equipment is correctly configured for the survey to be undertaken.

F5.2 Test process - Temperature

F5.2.1 The Contractor shall undertake an appropriate check of the temperature measurement System(s). The temperature measurement Systems should be within 1°C. If it is not then the System should be re-calibrated and a check on the performance repeated.

F5.3 Test process – Distance Measurement

F5.3.1 The Contractor shall undertake a check of the distance measurement System. This will be achieved by measuring the test length with the Equipment and comparing the results to the Reference Data. The distance measurement System should provide the same level of performance as that achieved at the Accreditation/Re-accreditation Trial. If the measurements are not within these requirements then the device should be re-calibrated and the performance check repeated.

F5.4 Test process - Deflection

F5.4.1 The Contractor should survey the Contractor's Calibration Site and process the Survey Data to obtain the Parameters listed in Table 7. The Contractor will then compare the Parameters against the Reference Data set and other relevant data collected for the site whilst under accredited status.

Table 7 - Parameters to be derived for the Contractor's Calibration Check

Parameter	Units	Reporting Interval
Location Referencing - National Grid Co-ordinates (if fitted)[1]	m	All test stations
Load-Normalised Deflection per Sensor Position	µm	All test stations
Temperature at 100mm Below Pavement Surface	°C	Each section of pavement construction
Pavement and air temperature (if fitted)	°C	All test stations

F5.4.2 It is expected that the deflection measurements collected on test sites will not necessarily be the same at every visit (for example, they will change with pavement temperature and subgrade condition). With no absolute reference measurement of deflection the assessment of the results is not straightforward. The Contractor is expected to have a basic understanding of the behaviour of pavements and the Equipment to determine that the deflection measurements are sensible when compared to the reference and other relevant data from the site (taking into consideration all other variables such as temperature).

F5.4.3 The location referencing Systems should be assessed to confirm that the Equipment is achieving a similar performance level to that achieved at the latest Accreditation/Re-accreditation trial.

F5.4.4 If a deviation from the expected performance trend is noted then the survey of the site must be repeated. If after three repeat runs, the differences still exist then the Auditor shall be immediately informed, and no further Surveys of the Network carried out until a resolution of the issue has been successfully demonstrated to the Auditor. The results of all surveys by the Equipment since the last successful Two Weekly Check are then considered suspect.

F5.4.5 The Contractor shall undertake an investigation to identify the source of error and, once resolved, demonstrate an acceptable performance through a successful QA check (the level of which is to be agreed with the Auditor).

F5.5 Reporting

F5.5.1 All Contractor's Calibration Check reports shall be supplied to the Auditor within 14 days of completion of the survey.

F5.5.2 The Survey Data for the Contractor's Calibration Checks shall be retained by the Contractor and Owner (if different) for examination by the Auditor if required. Any Contractor's Calibration Check Survey Data requested by the Auditor should be provided within 14 days of receipt of the request.

F.6 Two Weekly Check (no more than 20 days apart)

F6.1 Overview

F6.1.1 The aim of the Two Weekly Check is to provide a check on the medium term deflection data trending of the Equipment and to check that the calibration of the distance measurement system remains valid.

F6.1.2 Two Weekly Checks must be carried out during the Period of Work and be no more than 20 days apart. The site used for this check can be either the Contractor's Calibration Site or one of the Primary Check Sites.

F6.1.3 As part of the Two Weekly Check, the Contractor should also carry out a visual inspection of the Equipment for any obvious mechanical defects and that the Equipment and all of its Systems are operating correctly. The checks should ensure the Equipment is correctly configured for the survey to be undertaken.

[1] For monitoring the performance of the Equipment as part of the QA checks, the Location referencing data may be processed and reviewed as Latitude/Longitude data on systems where this is not automatically converted to OSGR data.

F6.2 Test process – Distance measurement

F6.2.1 The Contractor shall undertake a check of the distance measurement System. This will be achieved by measuring the test length with the Equipment and comparing the results to the Reference Data. The distance measurement System should provide the same level of performance as that achieved at the Accreditation/Reaccreditation trial. If the measurements are not within these requirements then the device should return to the Contractor's Calibration site to be re-calibrated and a check on the performance repeated.

F6.3 Test process – Deflection

F6.4 Tests for the Deflection data are the same as for the Contractor's Calibration Check.

F6.5 Reporting

F6.5.1 The results and records of the Two Weekly Checks shall be maintained by the Contractor for examination by the Auditor if required. Any Two Weekly Checks records requested should be provided to the Auditor within 14 days of receipt of the request.

F.7 Daily Check

F7.1 Overview

F7.1.1 The aim of the Daily Check is to provide a check on the condition and short term deflection data trending of the Equipment.

F7.1.2 As a minimum the Contractor must carry out a visual inspection and operational check of the Equipment and ensure the Equipment is operational and correctly configured for the survey to be undertaken.

F7.1.3 It is recommended that the Contractor also performs a before and after check on the performance of the Equipment.

F7.2 Test process – visual inspection and operational check

F7.2.1 Prior to any testing (and after any incident which may affect the Equipment) the Contractor must carry out a visual inspection of the Equipment for any obvious mechanical defects.

F7.2.2 As part of the operational check the Contractor must conduct a deflection measurement and assess the data. The Contractor is expected to have a basic understanding of the behaviour of pavements and the Equipment in order to determine that the deflection data are sensible. The data from this test may also be used as the reference data for the before and after check described below.

F7.2.3 The Contactor's Calibration Site and/or Primary Check Site(s) may be used for this test but it is likely that it would be impractical for the Equipment to visit these on a daily basis. Therefore a suitable test site should be identified for each test day, possibly close to the depot used for the overnight storage of the Equipment.

F7.2.4 The Survey Contractor should check that the Equipment is correctly configured for the survey

F7.3 Test process – before and after check

F7.3.1 Data for a before and after check should be collected prior to testing, at the end of the testing and every 24 hours in-between. So, for example, (for Monday to Friday - day shift working) the Contractor might collect data on Monday morning, with successive data collections either starting Monday evening or Tuesday morning, and finishing with a data collection on the Friday evening. It is possible some of the data collected may act as both the assessed data for the before and after check and the Reference Data for the next before and after check. However, the data used for the before and after check is ideally collected directly before and after each day's work.

F7.3.2 As the Equipment moves around the country, it may be necessary to carry out additional tests at the start or end of testing on other sites to ensure "closure" around every survey shift.

F7.3.3 The Equipment must be operating in the same configuration whilst collecting the data being assessed to that of the corresponding Reference Data.

F7.3.4 A before and after check site should have at least two test stations, which can be suitably identified so that they can be retested at another time. These test stations should be selected so that measurements can be taken safely and without unreasonable disruption to other users of the site.

F7.3.5 The Contactor's Calibration Site and/or Primary Check Site(s) may be used for the before and after check site but it is likely that it would be impractical for the Equipment to visit these on a daily basis. Therefore a suitable before and after check test site should be identified for each test day, possibly close to the depot used for the overnight storage of the Equipment.

F7.3.6 For a before and after check the Contractor should survey the selected test site and process the Survey Data, ideally on-board the equipment, to obtain the Parameters listed in Table 8.

Table 8 - Parameters to be calculated for the before and after check

Parameter	Units	Reporting Interval
Load-Normalised Deflection per Sensor Position	mm	All test stations
Temperature at 100mm Below Pavement Surface	°C	Each section of pavement construction

F7.3.7 For each before and after check, the Parameters listed in Table 8 will be compared to the results from the reference survey at the "start of day" to ascertain if the Equipment is measuring "as would be expected" for the conditions experienced during that particular survey. Any obvious deviations from the expected data trends should be noted (and highlighted to the Auditor).

F7.3.8 It is expected that the deflection measurements collected during the before and after check are likely to vary due to changes in pavement temperature. With no absolute reference measurement of deflection the assessment of the results is not straightforward. The Contractor is expected to have a basic understanding of the behaviour of pavements and the Equipment in order to determine that the deflection measurements from the two surveys are sensible when compared to each other, taking into consideration all variables (such as temperature).

F7.3.9 If a deviation from the expected performance trend is noted then another survey of the before and after check site should be undertaken. If, after three repeat runs, the differences still exist then testing should halt until the cause is identified. To support the investigation it may be necessary to return to the Contractor's Calibration site or a previous (recent) daily check site. The Contractor should repeat surveys that were conducted with the Equipment in the suspect condition and disregard the original data. The Auditor shall be informed as soon as practical (and no later than 14 days from the incident) of the issue and the steps taken to resolve it.

F7.4 Reporting

F7.4.1 The Contractor will provide the Auditor with a description of the procedures to be applied in the performance of Daily Checks, including the methods to be utilised for identifying the test stations.

F7.4.2 The records of the Daily Checks shall be maintained by the Contractor for examination by the Auditor if required. Any Daily Checks records requested should be provided to the Auditor within 14 days of receipt of the request.

F.8 Equipment Checks Following Routine Maintenance or alterations

F8.1 It is expected that between annual Re-accreditations of the Equipment, some Routine Maintenance or alterations may be required). The success of any maintenance should be verified with suitable QA checks ***before recommencing*** **surveys.** In most cases a successful Contractor's Calibration Check would provide a suitable level of QA. If the Contractor is uncertain on the suitable level of QA then they should contact the Auditor for advice.

F8.2 The records of the maintenance carried out and the checks undertaken following maintenance shall be maintained by the Contractor for examination by the Auditor if required. Any QA records requested should be provided to the Auditor within 14 days of receipt of the request.

Section G Quality Assurance checks by the Auditor

G.1 Checks on Contractor's QA

G1.1 One of the Auditor's roles is to carry out assessments of the Contractor's Quality Assurance procedures and offer advice where necessary.

G1.2 The Auditor may require the Contractor to demonstrate any aspect of their Quality Assurance regime at any time, through review of their documentation, or their data and records. The scope includes but is not limited to:

- Equipment operation and maintenance
- Calibration of the measurement Systems
- Driver and operative training and instruction
- Survey operation and record keeping
- Data recording, processing and analysis
- Delivery of Survey Data

G1.3 If there are doubts in the performance of the Equipment or the test procedure following the checks on the Contractor's QA or from other reports, then the Auditor may undertake additional spot checks as discussed below. Spot checks may also be conducted on request of the Employer.

G1.4 If during the Contractor's QA checks the Auditor identifies a lack of competence which may affect the ability of the Contractor to record and deliver good quality Survey Data then the Auditor may issue an Improvement Notice to the Owner and/or Contractor as discussed in Section H.

G.2 Additional investigations

G2.1 The Contractor may be subject to additional investigations on the operation and performance of their surveys. These investigations may include checks on survey planning, carrying out of the surveys, survey processing and/or quality procedures.

G2.2 Additional investigations may include, but are not limited to:

- A representative of the Auditor attending the premises of the Contractor to ensure that QA processes are being carried out to an appropriate standard. The Auditor will provide at least 5 working days' notice of the intention to carry out such an investigation.
- A representative of the Auditor accompanying the Contractor on randomly selected surveys to ensure that the surveys are being carried out to an appropriate standard. When requested, the Contractor shall provide the Auditor, with the current and anticipated location of the Equipment during the following 24 hour period and any access requirements of the site (if applicable), so that the Auditor can determine if it would be appropriate to undertake a Spot Check on the survey.
- An "Auditor's Repeat Survey"- this is where the Auditor will utilise accredited (and independent) Equipment to repeat a survey undertaken by the Equipment undergoing an investigation. The Auditor shall compare the data collected from the Independent Survey with the Contractor's survey and ascertain if the Equipment is measuring "as would be expected" for the conditions experienced during that particular survey. The Contractor shall be required to provide an explanation for any unexpected differences between the two surveys. This may include the Contractor re-surveying the test site to confirm the results of the original survey.

G2.3 If the additional investigation identifies a lack of competence or issue with the Equipment which may affect the ability of the Contractor to record and deliver accurate Survey Data then the Auditor may issue an improvement Notice to the Owner and/or Contractor as discussed in Section H.

Section H Improvement Notices

H.1 Improvement Notices procedure

H1.1 An Improvement Notice will detail the nature of the improvement required and a timescale over which it must be completed. It allows the Contractor to correct problems with their Equipment or Quality Assurance procedures.

H1.2 Being served with an Improvement Notice will not necessarily lead to withdrawal of Accreditation. However, failure to comply with the Improvement Notice within the given time frame will likely lead to withdrawal of Accreditation.

H1.3 The Improvement Notice will detail any restrictions to the use of the Equipment prior to satisfactory completion of the Improvement.

H1.4 The Auditor will inform the Employer of any Improvement Notices issued and changes of Accreditation status.

Appendix A Specification of DPT and devices that have previously gained accreditation

App A.1 Specification of DPT devices

App A.1.1 Loading Plate

App A.1.1.1 The plate through which the impact load is applied to the pavement should be circular and 300mm in diameter. It is important to ensure good contact between the plate and the pavement surface. To help achieve this, the loading plate may be split in to more than one segment. The plate may also incorporate a rubber pad with a grooved or similar pattern on the lower surface.

App A.1.2 Load Cell

App A.1.2.1 The load cell should have a measurement resolution of better than 0.1kN and a repeatability ±0.1% of its full scale range. The load cell should have a systematic error ≤ 0.5% of its full scale range and ≤2% of the reading (whichever is the greater).

App A.1.3 Pulse Shape

App A.1.3.1 The calculated stiffness of the pavement layers depends on the loading speed used. Ideally a DPT device should simulate as closely as possible the loading speed applied by a typical moving wheel. The shape of the impact pulse is described in terms of its rise time, which is the time from first onset of the waveform to the first peak in amplitude. It is also described in terms of the load pulse width which is the time from first onset of the pulse to the next point of zero amplitude. Table 9 shows the load pulse shape requirements for a DPT device.

Table 9 - Pulse shapes requirements for DPT devices

Parameter	Requirement
Peak Load	Target load ± 10%
Rise Time	Minimum 5 ms; maximum 15 ms
Pulse Width	Minimum 20 ms; maximum 60 ms

App A.1.4 Deflection Measurement

App A.1.4.1 The deflection bowl created by the impact is measured by a series of sensors radiating out from the centre of the plate. The type of sensor depends on the manufacturer of the machine but they are usually a seismic based sensor such as a geophone or seismometer. The sensors should have the ability to measure the deflection to a resolution of 1µm or better and have an accuracy of ±2% or 2µm (whichever is greater) or better.

App A.1.4.2 The minimum number of sensors available should be seven, including one at the centre of the plate. The remaining sensors must be adjustable to be located in radial positions from 200mm to 2100mm at a minimal spacing of 100mm. These sensors must be orientated in the same direction away from the test plate. Typically these sensors are aligned with the direction of travel.

App A.1.4.3 In addition to the sensors described above, some Equipment may be fitted with additional sensors aligned in the opposite direction from the test plate to test load transfer on joints.

App A.2 DPT devices that have previously gained accreditation

Table 10 – DPT devices that have previously gained accreditation

Manufacturer	Description	Model	Variants	Category
Dynatest	Falling Weight Deflectometer	8000	Trailer mounted	B
		8001	Trailer mounted	B
		8002	Trailer mounted	B
	Heavy Weight Deflectometer	8081	Trailer mounted	C
		8082	Trailer mounted	C
SWECO (Grontmij CarlBro)	Heavy Weight Deflectometer	PRI2100	Van integrated	C
			Trailer mounted	C
	Super Heavy Weight Deflectometer	PRI2100-S	Van integrated	D
			Trailer mounted	D
		PRI2500	Trailer mounted	D

Appendix B Requirements on the Auditor

App B.1 Roles of the Auditor

App B.1.1 As discussed in B.4 the Auditor is split into two main roles:

- Conducting and reporting the Accreditation/Re-accreditation process
- Monitoring the QA performed by the Contractor and conducting additional (within Period of Work) checks where necessary.

App B.1.2 These roles can be carried out by the same or by separate bodies. The requirements that these bodies must meet for these two roles are given in the sections below.

App B.1.3 The Auditor for Accreditation and Re-accreditation Trials will:

- Organise and host Accreditation and Re-accreditation Trials, including designing and developing the methodology of the trials, all administrative duties, arranging and maintaining suitable sites for Accreditation/Re-accreditation, together with the processing, interpretation and reporting of results.
- Periodically assess the performance of the site chosen for Accreditation/Re-accreditation so that the longer-term behaviour of the site can be monitored.
- Issue Accreditation Certificates showing the performance achieved by Equipment at the Accreditation/Re-accreditation Trial in a timely fashion. Typically this will be within 2-3 weeks of the corresponding Trial.
- Maintain a publically available list of Accredited Equipment.

App B.1.4 The QA Auditor will:

- Conduct checks on the QA conducted by the Contractor to the requirements of the Employer (offering advice where necessary).
- Where required, act as a technical advisor and intermediary to aid discussions between Contractor and Employer with regards to the quality of Survey Data.

App B.1.5 The Auditor will issue improvement notices to the Contractor/Owner if the Auditor identifies an issue with the Equipment, QA or survey process which could affect the quality of the Survey Data. Copies of these improvement notices will also be supplied to the Employer.

App B.2 Capabilities of the Auditor

App B.2.1 The Accreditation Auditor must:

- Have experience with the Survey Data produced by the Equipment and be knowledgeable on how to process and interpret it.
- Understand the implications of any differences in the Survey Data and how this is likely to affect the Employer.
- Demonstrate independence for their Auditor role.
- Have access to a suitable test site to undertake the Accreditation/Re-accreditation testing. In addition they must also have access to suitable supporting tools to provide the Reference Data and support the accreditation testing. The requirements for the test site and the Reference Data are given in Appendix C.

App B.2.2 The QA Auditor must:

- Have experience with the Survey Data produced by the Equipment and be knowledgeable on how to process and interpret it.
- Understand the implications of any differences in the Survey Data and how this is likely to affect the Employer.

Appendix C Site and Reference Data requirements for Accreditation/Re-accreditation

App C.1 Test site

App C.1.1 The Accreditation/Re-accreditation Trial will be held on a site that can be closed to traffic to ensure that testing can be completed in a controlled and safe environment.

App C.1.2 The Test site will be separated into at least nine test stations covering a wide range of deflections. Requirements for the test stations are further described in App C.2.

App C.1.3 The test site will contain a marked length to facilitate calibration of the Distance Measurement Instrument (DMI).

App C.1.4 The test site will contain one or more sections of straight and level pavement (minimum 500m) for the assessment of the DMI. The start and end points of this section(s) will be clearly marked (e.g. with a marker post and/or markings on the surface of the pavement).

App C.1.5 The test site will also contain a number of pre-drilled holes to facilitate the measurement of pavement temperature at a depth of 40mm and 100mm. The holes will be located so that measurements can be carried out during the course of the testing by the Contractor and the Auditor.

App C.2 Deflection test stations

App C.2.1 Repeatability testing will be conducted with a minimum of 6 tests. This may be achieved by undertaking 2 or more laps of a selection of at least 3 test stations or one lap of at least 6 test stations. The test stations and number of laps undertaken will be selected such that:

- At least one test station should have a nominal peak central DPT deflection under a 50 kN load at 20^0C (measured at a 100mm depth), of between 50 and 100 µm
- At least one test station should have a nominal peak central DPT deflection under a 50 kN load at 20^0C (measured at a 100mm depth), of between 300 and 400 µm
- The remaining test station/s should have deflection responses distributed between these two extremes
- At least one station should have fully flexible construction
- At least one station should be of rigid construction, mainly of pavement quality concrete

App C.2.2 Reproducibility testing will be conducted on a minimum of two test sets. This may be achieved by undertaking 2 or more laps of a selection of at least 9 test stations or by splitting one lap of at least 18 test stations into two test sets. The test stations and number of laps undertaken will be selected such that each test sets contains:

- At least one test station should have a nominal peak central DPT deflection under a 50 kN load at 20^0C (measured at a 100mm depth), of between 50 and 100 µm
- At least one test station should have a nominal peak central DPT deflection under a 50 kN load at 20^0C (measured at a 100mm depth), of between 300 and 400 µm
- The remaining test stations should have deflection responses distributed between these two extremes
- At least one station should have fully flexible construction
- At least one station should be of rigid construction, mainly of pavement quality concrete

App C.3 Reference Data

App C.3.1 Deflection – Repeatability

App C.3.1.1 The repeatability test is an assessment of the spread of the Survey Data from the Equipment and as such does not involve separately generated Reference Data.

App C.3.2 Deflection – Reproducibility

App C.3.2.1 The Reference Data for reproducibility (deflection assessment) is made up from at least three different currently Accredited Equipment that are representative of the currently Accredited Equipment. These representative Equipment must come from at least two different Owners

App C.3.3 Location Referencing – Distance

App C.3.3.1 The Reference Data for distance measurement is the elapsed distance for the distance measurement test section(s), as measured by the Auditor using an optical survey or other suitable method of comparable accuracy.

App C.3.4 Location Referencing – OSGR coordinates

App C.3.4.1 The Reference Data for OSGR measurement are the grid coordinates of the test stations measured by the Auditor using an independently calibrated location reference device such as a total station.

App C.3.5 Temperature

App C.3.5.1 Two sets of Reference Data will be collected for the assessment of temperature measurement.

- Temperature measurements independently collected by the Auditor using a suitable reference device.
- The average of the Fleet measurements provided at each temperature test hole.

App C.3.5.2 Two references shall be employed to assist in compensating for the variability observed between the constant temperature monitoring (as may be employed by the Auditor) and short term spot measurements (as will be employed by the Contractor).

App C.3.5.3 Both Reference Data sets will be used in the investigation and assessment of the supplied temperature data.

Appendix D Worked example of Deflection assessment for Accreditation/Re-accreditation Trials

App D.1 Repeatability

App D.1.1 Each Equipment undertakes surveys of the identified test stations and supplies the Survey Data to the Auditor. This data is checked and processed to generate the mean load and standard deviation of the load for the Equipment on each test station. These results are then examined to see if they meet the criteria for valid Repeatability survey data given in paragraph E4.2.4. An example of this process is given in Table 11.

Table 11 – Worked example of Suitability of Repeatability Survey Data

Equipment:	A
Target Load:	50kN

Station	Mean Load	Within 10% of Target?	StDev of load criteria	StDev of Load	Within criteria
I	55.2	**N**	1.10	1.06	Y
II	54.5	Y	1.09	1.08	Y
III	53.6	Y	1.07	1.08	**N**
IV	54.5	Y	1.09	1.07	Y
V	52.4	Y	1.05	1.04	Y
VI	52.6	Y	1.05	1.03	Y

App D.1.2 In the example given above Equipment 'A' did not provide suitable data for stations I and III. This Equipment would need to repeat this testing and provide data which meets the load requirements.

App D.1.3 Once the Equipment has provided suitable Repeatability data, the load corrected deflections are generated. Load correction is applied by dividing the deflection value by the load and then multiplying by the target load. Following calculation of the load corrected deflections the standard deviation criteria and the standard deviation of these load corrected deflections is generated. An example of this process for one station is given in Table 12.

Table 12 – Worked example of Repeatability Assessment

Equipment:	B

Station:	I	Deflection sensor						
		D1	D2	D3	D4	D5	D6	D7
Mean of Load corrected deflections:		464.0	375.8	237.2	143.3	83.7	49.9	30.0
SD criteria:		4.48	3.82	2.78	2.07	2.00	2.00	2.00
SD of Load corrected deflections:		0.45	0.60	0.39	0.41	0.41	0.27	0.43
Met criteria:		Y	Y	Y	Y	Y	Y	Y

App D.1.4 The process given above would be repeated for the other stations tested for the Repeatability assessment. This data would then be examined to identify if the Equipment produced a suitable percentage within the standard deviation criteria (see E4.2.6).

App D.2 Reproducibility

App D.2.1 Each Equipment undertakes surveys of the identified test stations and supplies the Survey Data to the Auditor. These surveys will need to be undertaken so that suitable Reference Data is obtained (see App C.3). This data is checked (including a check that the load applied is within a suitable tolerance of the target load) and processed to generate the load corrected deflections.

App D.2.2 The load corrected data is collected together and the average of the currently accredited Equipment (after removal of the highest and lowest measurements) is generated for each test station.

App D.2.3 FCF calculation

App D.2.3.1 For each Equipment, sensor and test station, the reference values are divided by the Equipment's mean deflection. These ratios are then averaged together to produce FCF values for each Equipment and sensor. These FCF values are also averaged together to produce an average value for the Equipment. An example of this process (for stations S1 to S9) is given in Table 13.

Table 13 – Worked example of FCF calculation

Equipment:	C

	Deflection sensor						
	D1	D2	D3	D4	D5	D6	D7
S1: Mean load corrected deflection	67.8	55.9	50.4	44.6	37.7	31.7	21.7
S1: Reference deflection	67.6	56.6	51.1	45.0	38.3	32.2	21.4
S2: Mean load corrected deflection	64.4	55.7	49.7	43.7	37.5	31.6	22.6
S2: Reference deflection	64.9	56.7	50.8	44.9	38.4	32.7	22.2

etc.

	Deflection sensor						
	D1	D2	D3	D4	D5	D6	D7
S1: Reference/Equipment's mean	0.997	1.013	1.014	1.009	1.016	1.016	0.986
S2: Reference/Equipment's mean	1.008	1.018	1.022	1.027	1.024	1.035	0.982
S3: Reference/Equipment's mean	1.004	1.006	1.005	1.026	1.008	1.016	1.008
S4: Reference/Equipment's mean	1.001	1.009	1.005	1.016	1.004	0.993	0.998
S5: Reference/Equipment's mean	1.003	1.004	1.005	1.002	1.006	0.986	1.055
S6: Reference/Equipment's mean	1.001	1.004	1.005	1.01	1.003	1.01	1.019
S7: Reference/Equipment's mean	1.004	1.004	1.005	1.006	1.003	1.019	0.969
S8: Reference/Equipment's mean	1.004	1.01	1.004	1.009	1.005	1.005	0.997
S9: Reference/Equipment's mean	1.055	1.002	1.02	1.005	1.002	1.005	0.979

	Deflection sensor							
	D1	D2	D3	D4	D5	D6	D7	Mean
FCF	1.009	1.008	1.009	1.012	1.008	1.009	0.999	1.008

App D.2.3.2 The FCF values generated would then be compared to the Deflection Reproducibility criteria given in Table 2 in section 0.

App D.2.4 SDDR calculation

App D.2.4.1 For each Equipment, sensor and test station, the reference deflection is subtracted from the Equipment's mean deflection and then divided by the reference deflection. These values are known as the deviation ratios. The standard deviation of these deviation ratios is calculated for each Equipment and sensor to produce the SDDR. The average of these sensor SDDRs is also calculated. An example of this process (using the same deflection data used for the FCF worked example above) can be seen in Table 14.

Table 14 – Worked example of SDDR calculation

Equipment:	C

	Deflection sensor						
	D1	D2	D3	D4	D5	D6	D7
S1: Deviation ratio	0.003	-0.012	-0.014	-0.009	-0.016	-0.016	0.014
S2: Deviation ratio	-0.008	-0.018	-0.022	-0.027	-0.023	-0.034	0.018
S3: Deviation ratio	-0.007	-0.017	-0.016	-0.028	-0.015	-0.019	-0.008
S4: Deviation ratio	-0.023	-0.021	-0.018	-0.015	-0.022	0.010	0.020
S5: Deviation ratio	-0.021	-0.004	-0.013	-0.001	-0.004	0.016	-0.040
S6: Deviation ratio	-0.020	-0.022	-0.012	-0.006	0.002	0.000	-0.007
S7: Deviation ratio	-0.024	-0.012	-0.008	-0.005	-0.025	-0.019	0.024
S8: Deviation ratio	-0.015	-0.010	-0.014	-0.005	-0.005	-0.003	-0.012
S9: Deviation ratio	-0.068	-0.024	-0.023	-0.011	-0.011	-0.009	0.016

	Deflection sensor							
	D1	D2	D3	D4	D5	D6	D7	Mean
SDDR	0.020	0.006	0.005	0.010	0.009	0.016	0.021	0.012

App D.2.4.2 The SDDR values generated would then be compared to the Deflection Reproducibility criteria given in Table 2 in section E4.3.

Appendix E QA Check sites summary

App E.1 QA Check sites summary

App E.1.1 The following table provides a summary of the requirements for the Quality Assurance check sites used in the Contractor's Quality Assurance. Further details of the sites and analysis required are given in Section F.

Table 15 – Summary details of Quality Assurance check sites

Site Type	Min length	Location referencing method	When should reference data be collected?	When should QA checks be carried out using this site?	Test site characteristics
Contractor's Calibration site	400m	The length of the distance check and calibration interval (minimum 400m) shall be measured using steel tape or other reliable device. Where required Grid reference co-ordinates shall be established for each test station on the test site.	Within 7 days of the Accreditation/Re-accreditation trial. If establishing a new Contractor's calibration site, within 7 days of a successful Contractor's Calibration Check (or Weekly Check if no suitable Contractor's Calibration data is available – consult with Auditor).	Within 7 days of the Accreditation/Re-accreditation trial. At the end of a Lay Off Period prior to conducting surveys No more than 40 days apart (while not in a Lay Off Period) Within 20 days of the last two Weekly check or Contractor's Calibration Check (when not in a Lay Off Period). This check can be carried out on a Primary Site instead. Before entering a Lay Off Period	This site should contain at least 6 test points. This site should contain sections of at least two different constructions at least one must be fully flexible pavement. The site must contain a test section of straight and level pavement for the assessment and calibration of distance measurements.
Primary Check Site(s) (Optional)	400m	The length of the distance check interval (minimum 400m) shall be measured using the measuring system on-board the Equipment or from another suitable device. Where required Grid reference co-ordinates shall be established for each test station on the test site.	Within 7 days of a successful Contractor's Calibration Check.	Within 20 days of the last two Weekly Check or Contractor's Calibration Check (when not in a Lay Off Period). This check can be carried out on the Contractor's Calibration site instead.	This site should contain at least 6 test points. This site should contain sections of at least one section of fully flexible pavement. The site must contain a test section of straight and level pavement for the assessment of distance measurements.
Daily check site	n/a	Test points should be suitably identified so that they can be retested at another time	Prior to the testing shift (see text for details)	At the end of the testing shift	This site should contain at least 2 test points.