

Accreditation and Quality Assurance of Deflectograph Survey Devices

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Contents

Definitions of terms used in this document	6
<i>Section A</i> Introduction.....	8
A.1 Introduction.....	8
A.2 Summary of the Accreditation and QA process	8
A.3 Structure of this document	10
<i>Section B</i> Roles of the relevant parties	11
B.1 Employer	11
B.2 Owner	11
B.3 Contractor.....	11
B.4 Auditor	11
<i>Section C</i> Equipment	13
C.1 Introduction.....	13
C.2 General Description	13
C.3 Additional Components	13
C.4 Calibration of the Equipment.....	13
<i>Section D</i> Accreditation.....	14
D.1 Introduction.....	14
D.2 Accreditation.....	14
D.3 The Accreditation Trial	14
<i>Section E</i> Re-accreditation	15
E.1 Introduction.....	15
E.2 Re-accreditation	15
E.3 Equipment inspection.....	15
E.4 Running Trials	16
E.5 Additional Tests.....	17
<i>Section F</i> Contractor's Quality Assurance.....	19
F.1 Introduction.....	19
F.2 Summary of the processes	19
F.3 The Contractor's Calibration site	19
F.4 Contractor's Calibration Check	20
F.5 Daily Check	22
F.6 Equipment Checks Following Routine Maintenance or alterations.....	25
<i>Section G</i> Quality Assurance checks by the Auditor.....	26
G.1 Checks on Contractor's QA.....	26
G.2 Additional investigations.....	26
<i>Section H</i> Improvement Notices	27
H.1 Improvement Notices procedure	27
<i>Appendix A</i> Requirements on the Auditor.....	28
App A.1 Roles of the Auditor.....	28
App A.2 Capabilities of the Auditor	28
<i>Appendix B</i> Site and Reference Data requirements for Accreditation/Re-accreditation	29
App B.1 Test site	29
App B.2 Deflection test sections	29
App B.3 Reference Data	29

Accreditation and QA of Deflectograph
Survey Devices

Appendix C Worked Example of Accreditation assessment 30
 App C.1 Deflection assessment 30
Appendix D QA check sites summary 32
 App D.1 QA Check sites summary 32

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, CS 229 (Design Manual for Roads and Bridges) or in the introduction to the Design Manual for Roads and Bridges (GG 101).

Accreditation Certificate; documentary evidence of the performance achieved during an Accreditation/Re-accreditation Trial. It also sets out the limitations and validity period of the accreditation. It shall 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 A. 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.

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 processes. The notice shall 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.

Accreditation and QA of Deflectograph Survey Devices

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.

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

Reference Data; data against which the Equipment shall 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, deflection 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 maintain the condition of the network. 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, CS 229 (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 shall be checked using a suitable Quality Assurance process.
- A1.3 An Accreditation and Quality Assurance programme has therefore been devised for Deflectograph 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 document sets out the requirements for Accreditation, Re-accreditation and Quality Assurance of Deflectograph surveys carried out to characterise road condition under CS 229.

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 shall 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 Deflectograph Accreditation and QA process is shown in Figure 1, and is described further in the following sub-sections.

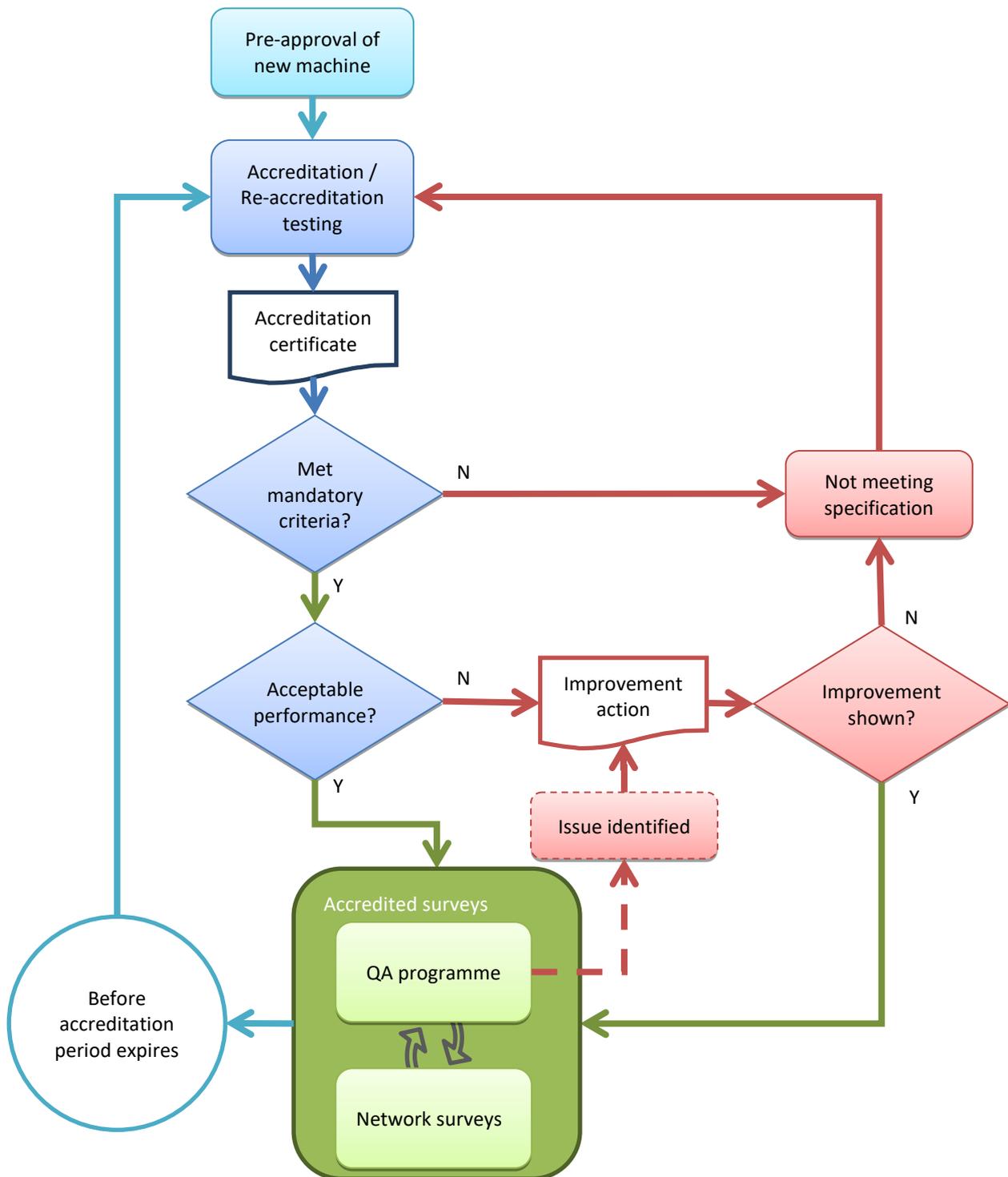


Figure 1: Outline of the Accreditation and Quality Assurance programmes

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 shall be determined by the Auditor.

A2.4 Accreditation/Re-accreditation Trial

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

Accreditation and QA of Deflectograph Survey Devices

- A2.4.2 Following completion of a Trial the Auditor shall issue an Accreditation Certificate. The Certificate shall 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 Auditor may revoke the Accredited status of the Equipment.
- 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 shall have a corresponding Accreditation Period. Owners/Contractors wishing to continue to undertake Accredited Surveys shall 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 Deflectograph 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 shall consider the requirements for Accreditation and QA ahead of appointing a survey contractor to undertake Deflectograph surveys:
- The Employer shall 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 shall require that the Contractor undertakes QA checks. These QA checks shall 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 shall nominate Auditor(s) to carry out checks. The Employer may conduct some or all of the Auditor's role internally. The Employer shall ensure that the Auditor(s) hold the required skills to undertake these checks and understand the results (see Appendix A).

B.2 Owner

- B2.1* Owners shall ensure that their Equipment is compliant with the equipment configuration and specification given in Section C.
- B2.2* Owners shall obtain Accreditation via an Accreditation/Re-accreditation trial prior to undertaking Accredited Surveys. 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 shall 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* The Owner should have their own ISO 9001 process and continue to undertake checks to support this. However, the Owner shall 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 shall 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 shall 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 shall 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 Contractor's Calibration 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 A.

Accreditation and QA of Deflectograph
Survey Devices

- 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 shall also be supplied to the Employer.

Section C Equipment

C.1 Introduction

- C1.1.1 The specification for measurement of deflection using a Deflectograph is given in the Design Manual for Roads and Bridges (DMRB); CS 229 *Data for pavement assessment*. The general description and additional components are described below.

C.2 General Description

- C2.1.1 The Equipment comprises a deflection measurement System combined with a distance measurement System. The Equipment is further described and defined in CS 229 and in LR834¹ (Pavement deflection: equipment for measurement in the United Kingdom, TRRL).
- C2.1.2 Equipment covered in this specification shall include a calibrated temperature probe for the direct measurement method as defined in CS 229.

C.3 Additional Components

- C3.1.1 Some Equipment may be fitted with a System to automatically identify section change points (e.g. using automatic detection of retro reflective markers), these allow for more accurate calibration of the distance measurement system of the Equipment.

C.4 Calibration of the Equipment

- C4.1 Sections D, E, and F of this document describe the Accreditation and QA 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:
- The dial gauge used for static calibration.
 - The temperature measurement System
 - The distance measurement System

¹ Kennedy, C.K., Fevre, P. and Clarke C.S. (1978). Pavement deflection: equipment for measurement in the United Kingdom. TRRL Laboratory Report 834. Crowthorne: Transport and Road Research 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 shall also show that all accredited Equipment are consistent within defined tolerances.

D1.2 Equipment shall 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 this 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 shall issue Accreditation Certificates showing the performance achieved by the Equipment. The Certificate should 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 shall also issue an Improvement Notice as detailed in Section H.

D2.3 Once the Equipment has been accredited it shall require Re-accreditation on 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 shall 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 therefore detail any additional assessments that shall 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 Equipment shall then be deemed to be authorised to take part in an Accreditation Trial.

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

E.2 Re-accreditation

E2.1 Following completion of a Re-accreditation Trial the Auditor shall issue Accreditation Certificates showing the performance achieved by the Equipment. The Certificate should 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 shall also issue an Improvement Notice as detailed in Section H.

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

E.3 Equipment inspection

E3.1 Contractors should be provided with an inspection check sheet which they shall complete and provide to the Auditor *in advance* of the Trial. The Contractors should also be asked to supply evidence that the required Calibrations have been performed (see section C.4).

E3.2 Equipment should also be inspected at the trial to ensure that they are in a suitable condition to conduct the tests. This should include verifying that the Equipment appears to be in good general mechanical order.

E3.3 Equipment shall be weighed so that Load normalisation of the survey data can be carried out. The Equipment shall be within the limits given in Table 1.

Table 1 – Criteria for wheel weights

Parameter	Acceptability Limit
Front Axle	4500 kg $\pm 5\%^2$
Twin rear wheel	3175 kg $\pm 10\%$

E3.4 A simple assessment of the temperature probe used for the direct measurement method should be carried out to make sure that it is producing consistent results.

E3.5 Equipment which has infra-red temperature sensors for determining surface temperature fitted should be checked to confirm that the emissivity settings have been set to the manufacturer's recommended setting for asphalt.

² It has been the experience in the Accreditation Trials that Equipment falling within 15% above the target limit for the front axle has performed acceptably with regards to deflection measurements. This matter has been investigated by TRL and Highways England. It has been concluded that, while consideration may be given to revising the specification limits at an appropriate point in the future, for the time being Equipment falling within this expanded front axle range would continue to be regarded as acceptable provided that they performed satisfactorily in the dynamic tests.

E.4 Running Trials

E4.1 Overview

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

E4.2 Deflection testing – Mandatory Requirement

E4.2.1 The assessment for Deflection measurements is described below, and a worked example is provided in Appendix C

E4.2.2 The Equipment shall undertake laps so that the following criteria are met:

- At least 5 laps are undertaken that comply with the requirements for Reference Data (see Appendix B, App B.3)
- Survey data shall be collected at a test speed of 2.4 ± 0.1 km/h. Equipment shall be checked by measuring the time taken to travel a known length. If the Equipment is found to be surveying outside the test speed range, the survey operator shall be asked to adjust their speed accordingly. Laps for Equipment where the survey speed requirements are not met shall be excluded from the assessment.
- Instances where the rate of change in temperature measured at 40mm is greater than 2.5°C per hour measured over a period of 15 minutes shall be investigated. If the variation of deflection data is seen to be to large then the lap should be disregarded and an additional lap undertaken.

E4.2.3 The Contractor shall supply the deflection measurements for their Equipment from each test lap in the file formats specified by the Auditor.

E4.2.4 The Auditor shall calculate:

- The load corrected mean for the Equipment for each wheel path and test section.
- The standard deviation of these mean values for the Fleet and for all of the Equipment at the trial, referred to as the Fleet between-Equipment standard deviation (BESD) and the Trial BESD. These values shall be used to assess the consistency of the Equipment at the Trial.
- The standard deviation of the deflection values between laps for the Equipment for each wheel path and test section. This data is referred to as the between-run standard deviation (BRSD). These values shall be used to assess the repeatability of each individual Equipment.

E4.2.5 The BRSD shall be used in the initial assessment of each Equipment. During the Tests, the BRSD values will be affected by the variability of pavement temperatures during the course of the testing. Therefore the performance shall be assessed by comparison against the performance of the other Equipment undertaking the Re-accreditation/Accreditation Tests.

E4.2.6 Where the BRSD values of the Equipment are significantly higher than the BRSD values of other individual Fleet Equipment, the data from the Equipment shall undergo further investigation by the Auditor to determine if the Equipment is suitable for Accreditation.

E4.2.7 The Trial BESD is acceptable if it is below the criterion given in Table 2. If the trial BESD exceeds this criterion then the data shall be further examined to identify outlying Equipment. This shall include examining the Fleet BESD and data from individual Equipment. Outlying Equipment shall be rejected and the data reassessed until the performance is acceptable.

E4.2.8 In addition, any Equipment that deviates by more than 3 times the BESD criterion from the Fleet Mean shall fail Accreditation. Any Equipment that is between two and three times the BESD criterion from the Fleet mean shall undergo further investigation by the Auditor to determine if the Equipment is suitable for Accreditation.

E4.2.9 The data from any Equipment rejected due to BRSD, BESD or otherwise identified as an outlier shall not be used in the calculation of the Reference Data (App B.3.1).

Table 2 – Criterion for Deflection measurements

Parameter	Acceptability Limit
Between Equipment standard deviation (BESD)	$\leq 0.0257 * \text{Reference Data} + 9.88 \text{ (}\mu\text{m)}$

Accreditation and QA of Deflectograph
Survey Devices

E4.2.10 The performance shall be assessed for both wheel paths separately. To achieve Accreditation the Equipment shall meet the requirements for both the NS wheel path and the OS wheel path.

E4.2.11 In addition to the above assessments the Auditor should review the profiles of the Survey Data over the site for each Equipment and investigate any anomalies. Based on the results of the investigation the Auditor may withhold Accreditation for Equipment and/or issue an Improvement Notice as detailed in Section H.

E4.3 Location Referencing (Distance) – Mandatory Requirement

E4.3.1 Accreditation of an Equipment's ability to measure distance is carried out by comparing its measurements of a test length with the Reference Data (App B.3.2), repeated at least five times. The criteria applied to the test measurements are given in Table 3. Note: the tolerance allows for the basic method by which events are recorded in Deflectograph Survey Data.

Table 3 – Criteria for Measurement of Distance travelled

Parameter	Acceptability Limit
Distance measured	≥80% within 5m

E.5 Additional Tests

E5.1 Overview

E5.1.1 The criteria in this sub-section are specified as High, Medium and Low levels of performance. This reflects the lower level of maturity of this test. In future revisions to this document these may become mandatory criteria.

E5.1.2 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 Temperature measurement – direct measurement method

E5.2.1 If undertaking this test, the Contractor should be required to make measurements from holes supplied by the Auditor (40mm depth) so that at least eight measurements are taken during the course of the test laps. These probes are required to provide results to a resolution equal to or better than 0.1 °C. Therefore if the probe does not then it shall be identified as “Not Suitable” regardless of the performance seen for the measurements (with a note identifying the reason for the performance given). The criteria for the assessment of the direct measurement method are given in Table 4.

Table 4– Criteria for direct measurement method

Performance level	Measurement of temperature
High	≥80% of the measurements are within 1.0°C of the reference
Medium	≥50% of the measurements are within 1.0°C of the reference
Low	≥15% of the measurements are within 1.0°C of the reference
Not Suitable	Otherwise

E5.3 Temperature measurement –Contactless measurement

E5.3.1 If undertaking this test, the Contractor shall be required to make measurements of the air and surface temperature (at locations specified by the Auditor) so that at least eight pairs of measurements are taken during the course of the test laps. These sensors are required to provide results to a resolution equal to or better than 0.1 °C. Therefore if the sensor does not then it shall be identified as “Not Suitable” regardless of the performance seen for the measurements (with a note identifying the reason for the performance given). The criteria for the assessment of surface temperature measurement are given in Table 5 and the assessment of air temperature measurement are given in Table 6.

Table 5– Criteria for surface temperature measurement

Performance level	Measurement of temperature
High	≥80% of the measurements are within 1.0°C of the reference
Medium	≥50% of the measurements are within 1.0°C of the reference
Low	≥15% of the measurements are within 1.0°C of the reference
Not Suitable	Otherwise

Table 6– Criteria for air temperature measurement

Performance level	Measurement of temperature
High	≥80% of the measurements are within 1.0°C of the reference
Medium	≥50% of the measurements are within 1.0°C of the reference
Low	≥15% of the measurements are within 1.0°C of the reference
Not Suitable	Otherwise

E5.3.2 In addition to providing the air and surface temperatures the Survey Contractor shall provide the predicted temperature at 40mm depth using this data. The Auditor may allow Survey Contractors to provide these predicted temperatures after the trial to allow for processing time. The Auditor shall confirm on the Accreditation Certificate whether the calculations have been accurately calculated.

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 shall cover all aspects of the surveys including, but not limited to:

- Equipment operation and maintenance
- Calibration of the Equipment, including servicing and calibration of the dial gauge at least annually
- Driver and operator training and instruction – the Equipment shall 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 shall be undertaken:

- 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 6 weeks 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 additional 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

F3.1 The Contractor shall establish a Contractor's Calibration site to achieve the QA test programme. The site chosen by the Contractor should be reported to the Auditor. The site may be subject to monitoring by the Auditor at any time.

F3.2 If the condition of the Contractor's Calibration site is affected by maintenance or other external factors at any time, the Contractor shall 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 highway authority responsible for the test site location and obtain its agreement before making any marking on or modification of the site.

F3.4 A summary of the requirements for the Contractor's calibration site is given in Appendix D.

F3.5 The site

F3.5.1 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.

F3.5.2 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 shall contain:

- At least two sections, each producing different levels of deflection (ideally significantly different to each other). These sections should contain at least two different construction types. At least one of the sections shall be of flexible with an asphalt base construction. Each section should be at least 50m in length and contain reasonably uniform deflections within the section.

Accreditation and QA of Deflectograph Survey Devices

- A length of at least 400m of straight and level pavement for the assessment and calibration of distance measurements.

F3.5.3 It may be necessary to form the Contractor's Calibration site from 2 or more locations to meet these requirements.

F3.5.4 Other factors that shall be considered when defining a site include:

- The sections should not be too heavily trafficked, thus giving a long useful life as calibration lengths. Low traffic levels should also make it easier to visit the site on a regular basis.
- The drainage should be satisfactory so as to keep the seasonal variation of results to a minimum.
- Each section should have a uniform road surface and not be subject to sun/shadow effect making it difficult to determine pavement temperatures accurately.
- If the pavement contains hydraulically bound material it should be uncracked otherwise the deflection profile is liable to be excessively variable.
- The surface course of any type of pavement should be in sound, uncracked condition, preferably with wheel-track rutting less than 5 mm deep. This requirement may be difficult to attain where a pavement with high deflections is required and a lesser standard may have to be accepted. However, rut depths of 10 mm should be considered the absolute maximum.
- To help investigate differences between the NS and OS beams, consideration should be given to the potential ability to safely conduct either offset testing or testing the site travelling in the opposite direction (so that one or both of the beams traverse the line normally surveyed by the other). In the case of a site where testing in the opposite direction can occur (likely to be a closed or private road), the gradient of the road should not exceed 4% as a steeper gradient is likely to have an adverse effect on the results.

F3.5.5 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.

F3.5.6 Locational Reference data should be obtained on the site in the form of the length measured to an accuracy of $\pm 0.5\text{m}$, using steel tape or other reliable device.

F3.5.7 The test site Reference Data shall include all of the Survey Data and derived Parameters required for the corresponding QA test (see Table 7).

F3.5.8 The Survey Data obtained from the reference survey shall 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.

F3.5.9 The Contractor should carry out more than one survey at the test site when collecting the Reference Data as a measure of consistency and repeatability.

F3.5.10 In some cases it may be necessary or desirable to establish a new Contractor's Calibration Site. This shall 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.

F.4 Contractor's Calibration Check

F4.1 Overview

F4.1.1 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.

F4.1.2 During periods of surveying (i.e. not during a Lay Off Period) Contractor's Calibration Checks shall be carried out no more than 6 weeks apart. However, to reduce risk to the Contractor, it is recommended that they are conducted on a monthly basis. The site used for this check shall be the Contractor's Calibration Site.

F4.1.3 As part of the Contractor's Calibration Check, the Contractor shall 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.

F4.2 Test process –temperature

F4.2.1 The Contractor shall undertake an appropriate check of the temperature measurement System(s). The temperature measurement Systems shall be accurate to within 1°C. If it is not then the System shall be re-calibrated and a check on the performance repeated.

F4.3 Test process – Distance measurement

F4.3.1 The Contractor shall undertake a check of the distance measurement System. This shall be achieved by measuring the test length with the Equipment and comparing the results to the Reference Data. The distance measurement System shall provide the same performance as required at the Accreditation/Re-accreditation Trial (see E4.3). If the measurements are not within these requirements then the device shall be re-calibrated and the performance check repeated.

F4.4 Test process – Deflection

F4.4.1 The Contractor should conduct a minimum of three runs of the Contractor’s Calibration Site and shall process the Survey Data to obtain the Parameters listed in Table 7. If the site is sufficiently well known to allow for the calculation of temperature corrected deflections, it is recommended that this data is also inspected. The Contractor shall then compare the Parameters against the Reference Data set and other relevant data previously collected for the site (whilst under accredited status).

Table 7 - Parameters to be calculated for the Contractor’s Calibration Check

Parameter	Units	Reporting Interval
Load corrected deflection data	µm	Average for each test section
Temperature at 40mm Below Pavement Surface	°C	Each section of pavement construction
Pavement surface and air temperature (if available)	°C	Average for each test section

F4.4.2 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) and taking into consideration all variables (such as temperature). Some suggested criteria for the deflection measurements are given in Table 8.

Table 8 - Suggested performance criteria for the Contractor’s Calibration Check.

Parameter	Units	Criteria
Load corrected deflection data	µm	Within 0.1*Reference mean deflection+40 of the previous visit and consistent with expected trends based on changes in temperature
Load and temperature corrected Deflection data (optional)	µm	Within 0.05 * Reference mean deflection +20

F4.4.3 If a deviation from the expected performance trend is noted then the survey of the site shall 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 previous successful Contractor’s Calibration Check are then considered suspect.

F4.4.4 The Contractor shall undertake an investigation to identify the source of error and, once resolved, demonstrate an acceptable performance through a successful QA check (level of which is to be agreed with the Auditor).

Accreditation and QA of Deflectograph Survey Devices

F4.5 Reporting

- F4.5.1* All Contractor's Calibration Check reports shall be supplied to the Auditor within 14 days of completion of the survey.
- F4.5.2* The Survey Data for the Contractor's Calibration Checks shall be retained by the Contractor and Owner (if different) for examination by the Auditor as required. Any Contractor's Calibration Check Survey Data requested by the Auditor shall be provided within 14 days of receipt of the request.

F.5 Daily Check

F5.1 Overview

- F5.1.1* The aim of the Daily Check is to provide a check on the operational capacity of the Equipment. Checks and calibrations that shall be carried out include (but are not limited to);
- Checks on survey frame condition
 - Check on vehicle
 - Static Calibration

F5.1.2 The Contractor shall provide the Auditor with a description of the procedures to be applied in the performance of Daily Checks.

F5.1.3 It is recommended that checks are also carried out during the survey shift e.g. recalibration when beam arm is changed or adjusted etc.

F5.2 Test process – checks on survey frame and vehicle condition

F5.2.1 The Contractor should carry out a visual inspection of the Equipment for any obvious mechanical defects and to check 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.

F5.3 Test process – Static Calibration

F5.3.1 The testing part of a survey shift should be completed no more than twelve hours after a static calibration. If the testing continues beyond the twelve hour limit then the static calibration should be repeated in order to achieve this. In cases where this cannot be achieved then the static calibration shall be carried out as soon as possible. In addition, both the Employer and the Auditor shall be informed that this has occurred and the reason for its occurrence.

F5.3.2 Static calibration is influenced by the state of maintenance of the machine and calibration equipment and the accuracy with which the operator achieves input movements at the beam tip. The conditions under which calibration is carried out can also affect the result achieved. In particular, the roadside is sometimes not a suitable place to achieve the calibration specified. It may be preferable to do the required Static Calibration at the overnight base.

F5.3.3 Prior to undertaking a Static Calibration, the recording equipment may need a warming-up period (see makers instructions).

F5.3.4 Particular attention shall be paid to calibration as deflection measurements are small, typically in the range 0 to 0.5mm.

F5.3.5 The static calibration shall be carried out in the following manner:

- The calibration rig used for transmitting movements to the beam tip shall be the type recommended by the Equipment manufacturer.
- The dial gauge shall be mounted on a separate baseplate and shall be positioned vertically with the measuring point placed on the beam over the point of contact of the beam tip with the road.
- Three separate movements at the beam tip of offside and nearside beams shall be made for each input value between zero and 1mm.
- The dial gauge and the recording system shall be returned to zero between each input movement

F5.3.6 The results of the calibration set shall be compared with the appropriate limits specified in Table 9 using the test method outlined in Figure 2 and described in the paragraphs below.

Table 9 – Static Calibration

Beam Tip Input Level (mm x 10 ⁻²)	Digital Output (mm x 10 ⁻²)	
	Tolerance*	Max Range**
10	+1/-2	2
20	±1	2
30	±1	2
40	±1	2
50	±1	2
60	±2	3
80	±2	3
100	+4/-2	3

Three separate movements at beam tip are required for each input value making up a calibration set.
 * for each reading
 ** for each set of readings

- F5.3.1 If the results are within the limits then the survey may proceed. If the results at only one input level are out of specification, calibration at that input level shall be repeated, but 5 input movements are then required. The tolerance and range of 4 out of 5 of these are to be in the specification before the survey may proceed.
- F5.3.2 If the tolerance is not met for this repeat or more than one input level is outside of the tolerance, then the calibration rig shall be removed and repositioned. A second static calibration shall be carried out (applying the same approach as above). If the second calibration set is out of specification, reference should be made to the Equipment manufacturers' Operators Instruction Manual to determine the likely cause and recommended course of action. A minimum of two calibration sets which comply with the specification shall then be achieved before the machine may be considered fit for surveys. If this is not achieved then the survey (using this Equipment) shall be abandoned, the Auditor notified and the Equipment investigated.
- F5.3.3 The calibration values that are entered into the computer program for calibration correction shall be the mean of all the results of calibration sets taken on the day of the survey that have complied with the specification.
- F5.3.4 The records of Static Calibrations shall be examined by the operators for consistency at least every two weeks during periods of operation. If any serious trends or substantial variations are found in the calibration then this shall be investigated and reported to the Auditor.

Accreditation and QA of Deflectograph Survey Devices

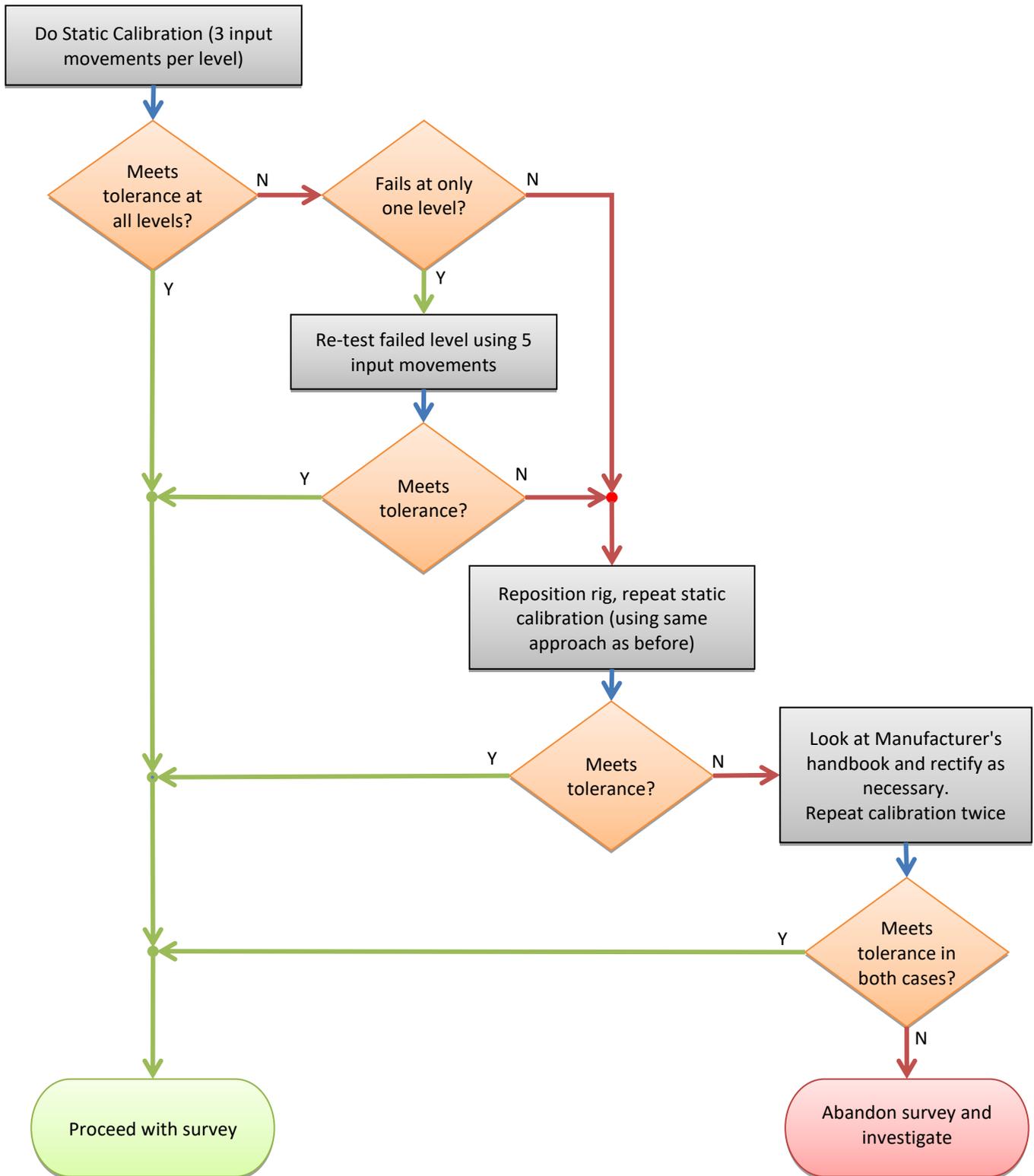


Figure 2: Flowchart for static calibration

F5.4 Reporting

F5.4.1 The records of the Daily Checks shall be maintained by the Contractor for examination by the Auditor as required. This shall include all values obtained during Static Calibrations. Any Daily Checks records requested shall be provided to the Auditor within 14 days.

F.6 Equipment Checks Following Routine Maintenance or alterations

- F6.1.1* It is expected that between annual re-accreditations of the Equipment, some Routine Maintenance or alterations may be required. The success of the maintenance shall 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.
- F6.1.2* If the maintenance/modification undergone has (or may) change the weight (or weight distribution) of the Equipment then the Equipment shall be reweighed and the new weight values used when processing surveys conducted following the change in weight (or weight distribution). The new weight shall be within the limits given in Table 1 (and the corresponding footnote). The Contractor shall successfully perform a Contractor's Calibration Check using the new weight values to show consistency with previous performance before undertaking any further Accredited Surveys.
- F6.1.3* 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 shall 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 any doubts as to 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 investigations as discussed below. Additional investigations may also be conducted if requested by the Employer.
- G1.4 If during checks on the Contractor's QA 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 may attend the premises of the Contractor to ensure that QA processes are being carried out to an appropriate standard. The Auditor shall provide at least 5 working days notice of the intention to carry out such a Spot Check.
 - A representative of the Auditor may accompany 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 for 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" (ARS) is where the Auditor shall utilise a different accredited Equipment to repeat a survey undertaken by the Equipment undergoing the investigation. The Auditor shall determine whether another Equipment from the same Owner is suitable for this test, or if Equipment from a different Owner shall be used. Due to the logistics of arranging Deflectograph surveys on a live network, the test is likely to be a repeat survey of the Contractor's Calibration Site. The Auditor shall compare the data collected from the ARS 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* The Improvement Notice shall detail the nature of the improvement required and a timescale over which it shall 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* If the Improvement Notice results in the withdrawal of Accreditation the Auditor shall review the data and the circumstances to determine if the Equipment would be required to attend a re-accreditation trial to demonstrate the improvement. However the Auditor may identify a different route to demonstrate the improvement if a suitable one exists.
- H1.4* The Improvement Notice shall detail any restrictions to the use of the Equipment prior to satisfactory completion of the improvement.
- H1.5* The Auditor shall inform the Employer of any Improvement Notices issued and changes of Accreditation status.

Appendix A Requirements on the Auditor

App A.1 Roles of the Auditor

- App A.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 A.1.2 These roles can be carried out by the same or by separate bodies. The requirements that these bodies shall meet for these two roles are given in the sections below.
- App A.1.3 The Auditor for Accreditation and Re-accreditation Trials shall:
- 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. This should be within 2-3 weeks of the corresponding Trial.
 - Maintain a publically available list of Accredited Equipment.
- App A.1.4 The QA Auditor shall:
- 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 A.1.5 The Auditor shall 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 shall also be supplied to the Employer.

App A.2 Capabilities of the Auditor

- App A.2.1 The Accreditation Auditor shall:
- 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 shall 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 B.
- App A.2.2 The QA Auditor shall:
- 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 B Site and Reference Data requirements for Accreditation/Re-accreditation

App B.1 Test site

- App B.1.1 The Accreditation/Re-accreditation Trial shall 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 B.1.2 The Test site shall be separated into at least three test sections covering a wide range of deflections. Where possible each section should be approximately 100m in length, but no shorter than 50m. These sections shall also be located such that the Equipment can maintain the test speed safely throughout its length. Requirements for the test sections are further described in App B.2.
- App B.1.3 The test site should contain a marked length of 400m to facilitate calibration of the Distance Measurement Instrument (DMI). If used, the start and end points of this section shall be clearly marked (e.g. with a marker post and/or markings on the surface of the pavement).
- App B.1.4 The test site shall 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) shall be clearly marked (e.g. with a marker post and/or markings on the surface of the pavement).
- App B.1.5 The test site should contain a number of pre-drilled holes to facilitate the measurement of pavement temperature at a depth of 40mm. The holes should be located so that measurements can be carried out during the course of the testing by the Contractors and the Auditor.

App B.2 Deflection test sections

- App B.2.1 Deflection test sections should be relatively uniform in terms of construction and deflection response and shall include:
- At least one test section which has an average peak deflection in each wheel path, at a 40mm depth pavement temperature of 20°C under a 3175kg wheel load, of less than 200 microns and preferably less than 100 microns.
 - At least one test section which has an average peak deflection in each wheel path, at a 40mm depth pavement temperature of 20°C under a 3175kg wheel load, of greater than 300 microns and preferably greater than 400 microns.
- App B.2.2 The remaining test section(s) should have average deflection responses distributed between those of the sections specified above.

App B.3 Reference Data

App B.3.1 Deflection

- App B.3.1.1 The Reference Data for the deflection assessment is made up from at least three different currently Accredited Equipment that are representative of the currently Accredited Equipment. These representative Equipment shall come from at least two different Owners.

App B.3.2 Location Referencing – Distance

- App B.3.2.1 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 a suitably calibrated and accurate distance measurement device.

App B.3.3 Temperature

- App B.3.3.1 Two sets of Reference Data shall 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 B.3.3.2 These two references should be employed to assist in compensating for the variability observed between stable ongoing temperature monitoring (as may be employed by the Auditor) and short term spot measurements (as will be employed by the Contractor). Both Reference Data sets should be used in the investigation and assessment of the supplied temperature data.

Appendix C Worked Example of Accreditation assessment

App C.1 Deflection assessment

App C.1.1 **Between run standard deviation (BRSD) and Load corrected means**

- App C.1.1.1 Each Equipment undertakes repeat surveys of the test sections and supplies the deflection Survey Data to the Auditor. This is processed to produce load corrected mean deflection values for each section, wheel path and survey. Load normalisation is achieved by dividing the deflection value by the weight (in kg) for the rear wheel in the appropriate wheel path and multiplying by the standard dual wheel load in kg (3175).
- App C.1.1.2 These values are then processed to produce the mean deflection and the BRSD for each section and wheel path. An example of this for one Equipment (referred to as Equipment "A") is shown in Table 10.
- App C.1.1.3 The BRSD values are calculated for each Equipment and then compared. An example of this data is shown in Table 11 for six different Equipment, A to F.
- App C.1.1.4 During the analysis of the BRSD values the Auditor may also examine plots of deflections within the sections to see if variability has been caused by differences in test line and other effects.

Table 10 – Calculation of load corrected mean and BRSD for Equipment A

	Load corrected mean deflection (µm)					Load corrected mean (µm)	BRSD (µm)
	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5		
NS Section 1	16.6	28.4	16.0	15.5	17.1	18.7	5.44
OS Section 1	23.6	23.1	16.1	21.4	16.1	20.1	3.71
NS Section 2	241.7	257.3	316.2	338.7	339.2	298.6	46.12
OS Section 2	240.7	256.3	315.2	336.7	337.2	297.2	45.69
NS Section 3	135.5	127.8	165.5	180.0	169.7	155.7	22.74
OS Section 3	134.0	151.2	170.0	179.6	176.9	162.3	19.34

Table 11 – Calculation of load corrected mean and BRSD

	Between Run Standard Deviation (µm)					
	Section 1		Section 2		Section 3	
	NS	OS	NS	OS	NS	OS
Equipment A	5.44	3.71	46.12	45.69	22.74	19.34
Equipment B	5.02	4.59	37.10	36.76	14.71	12.96
Equipment C	5.42	3.37	33.20	35.47	24.88	17.87
Equipment D	4.33	8.91	45.55	46.17	34.24	26.41
Equipment E	9.50	9.91	36.83	36.94	10.09	12.27
Equipment F	5.95	6.47	38.04	38.36	10.31	10.61

App C.1.2 **Between-Equipment standard deviations (BESD), Fleet means and BESD criteria**

- App C.1.2.1 The load corrected means are calculated for each Equipment. The average and standard deviation of each of these values is calculated for each of the wheel paths on each section and for the site as a whole. These Average values are known as the Trial Mean and the standard deviation is known as the Trial Between-Equipment Standard Deviation (BESD).
- App C.1.2.2 The average and standard deviation of the Fleet (the Equipment which currently has Accredited status) is also calculated and this is referred to as the Fleet Mean and the Fleet BESD.
- App C.1.2.3 The BESD criteria are calculated from the Trial Mean using the formula in Table 2. The Trial BESD is deemed unsuitable if it exceeds the respective BESD criteria. If the Trial BESD exceeds the criterion

Accreditation and QA of Deflectograph Survey Devices

then the Fleet BESD is examined (using the criteria calculated from the Fleet Mean). The data from individual Equipment shall also be investigated to identify outliers.

App C.1.2.4 In addition Equipment is marked as requiring investigation if its load corrected mean is more than 2 x BESD criterion away from the Fleet Mean, and shall not receive Accreditation if it is more than 3 x BESD criterion away from the Fleet Mean.

App C.1.2.5 An example of these values is given in Table 12 (in this case all of the Equipment taking part in the trial are part of the Fleet and therefore the Trial and Fleet values are the same). Instances where the BESD does not meet the criteria are highlighted in red. Instances where an Equipment's load corrected mean is more than 3 x BESD criteria away from the Fleet mean are also highlighted in red, and if it is more than 2 x BESD criteria it has been highlighted orange.

App C.1.2.6 It can be seen that Equipment C is consistently greater than the Fleet Mean. This Equipment is consistently between 2 and 3 times the BESD criteria for the NS wheel path. Although not resulting in an immediate removal from Accreditation, it is flagged for investigation. It can also be seen that for the NS data, the BESD values exceed the criteria. Therefore Equipment C would not receive Accreditation for NS deflections. This machine is then removed from the analysis of the NS deflections and the Fleet Mean, BESD and BESD for the NS wheel path are recalculated. These new values can be seen in Table 13.

App C.1.2.7 These new BESD values are all within the BESD criteria, therefore the Accreditation Certificate for Equipment C would state that only the OS deflections were Accredited.

Table 12 – Calculation of Fleet Mean and Between Equipment Standard Deviation (BESD)

	Load corrected Mean							
	Section 1		Section 2		Section 3		For the site	
	NS	OS	NS	OS	NS	OS	NS	OS
Equipment A	18.7	20.1	298.6	297.2	155.7	162.3	157.7	159.9
Equipment B	24.9	21.8	292.8	291.0	143.0	143.5	153.6	152.1
Equipment C	50.7	40.0	337.4	324.8	186.2	178.1	191.4	181.0
Equipment D	31.0	20.3	297.5	295.7	168.9	150.9	165.8	155.6
Equipment E	17.8	18.8	279.8	280.0	133.3	142.2	143.6	147.0
Equipment F	22.9	27.9	302.4	300.6	149.5	159.1	158.3	162.5
Fleet Mean	27.7	24.8	301.4	298.2	156.1	156.0	161.7	159.7
Fleet BESD	12.23	8.11	19.28	14.85	19.01	13.51	16.25	11.80
BESD criteria	10.59	10.52	17.63	17.54	13.89	13.89	14.04	13.98

Table 13 – Calculation of Fleet Mean and Between Equipment Standard Deviation (BESD)

	Section 1		Section 2		Section 3		For the site	
	NS	OS	NS	OS	NS	OS	NS	OS
Fleet Mean	23.1	24.8	294.2	298.2	150.1	156.0	155.8	159.7
Fleet BESD	5.31	8.11	8.76	14.85	13.40	13.51	8.10	11.80
BESD criteria	10.47	10.52	17.44	17.54	13.74	13.89	13.88	13.98

Appendix D QA check sites summary

App D.1 QA Check sites summary

App D.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 14 – Summary details of Quality Assurance check sites

Site Type	Minimum length	Location referencing method	When shall reference data be collected?	When shall 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.	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.	Within 7 days of the Accreditation/Re-accreditation trial	The site should contain at least two different construction types at least one of which shall be fully flexible. The site shall contain a test section of straight and level pavement for the assessment and calibration of distance measurements
				At the end of a Lay Off Period prior to conducting surveys	
				No more than 6 weeks apart while not in a Lay Off Period	
				Before entering a Lay Off Period	