T-LEVELS | Institute for Apprenticeships & Technical Education

T Level Technical Qualification in Science

Occupational specialism assessment (OSA)

Metrology Sciences

Assignment 2

Mark scheme

v1.3: Specimen assessment materials
21 November 2023
603/6989/9

Internal reference: SCI-0012-02

NCFE CACHE

T Level Technical Qualification in Science
Occupational specialism assessment (OSA)

Metrology Sciences

Mark scheme

Assignment 2

Contents

Task 1

PO1 and PO2

Metrology measurement plan

Band	Mark	Descriptor
4	16–20	The student has provided a plan that: • evaluates all methods for measurement, inspection and recording • clearly explains processes used • gives relevant and well-reasoned justifications throughout • identifies all major hazards with reference to technical and legal requirements • explains in detail realistic recommendations on how to mitigate all risks and environmental factors • classifies all equipment correctly • uses relevant industry standard terminology throughout **Note:** Please note that the uncertainty budget is marked separately; see the marking grid below this one.
3	11–15	The student has provided a plan that: • explains the processes used for measurement, inspection and recording • uses relevant and realistic reasoning throughout • identifies most major hazards with reference to technical and legal requirements • describes recommendations on how to mitigate key risks and environmental factors • classifies all equipment with some, but minimal, error • uses relevant industry standard terminology with some, but minimal, error
2	6–10	The student has provided a plan that: • describes most processes used for measurement, inspection and recording in some detail, but insufficient to reliably replicate • identifies some major hazards with reference to technical and legal requirements • identifies how to mitigate some risks and environmental factors • attempts to classify some equipment with some patterns of error • attempts to use relevant industry standard terminology with some patterns of error
1	1–5	The student has provided a plan that: • identifies some processes used for measurement, inspection and recording, giving limited details • identifies some major hazards • lists some basic mitigation of some risks and environmental factors, although these may be based on common sense or general assertions rather than occupational knowledge in context • attempts to classify some equipment with consistent error • attempts to use relevant industry standard terminology with consistent error
0	0	No creditworthy material as described in bands 4 to 1.

PO1

Uncertainty calculation within the plan

Band	Mark	Descriptor
3	7–9	The student has: • explained their consideration of uncertainty in measurement in detail, giving detailed reference to the equipment and the environment, for example, vibration, debris, dust, background light, temperature and humidity, type of workshop (metrology lab) • explained in detail realistic recommendations for mitigating possible uncertainty risks • demonstrated both type A and type B uncertainty in the uncertainty budget calculation and explained the outcome
2	4–6	The student has: • described their consideration of uncertainty in measurement, which is basic but relevant to the equipment and the environment, for example, vibration, debris, dust, background light, temperature and humidity, type of workshop (metrology lab) • described some relevant suggestions for mitigating possible uncertainty risks • demonstrated both type A and type B uncertainty in the uncertainty budget calculation
1	1–3	The student has: • listed their considerations of uncertainty in measurement in limited detail, which is somewhat relevant to some of the equipment and the environment, for example, vibration, debris, dust, background light, temperature and humidity, type of workshop (metrology lab) • attempted to identify suggestions to mitigate uncertainty risks but these may be unrealistic or based on common sense/general assertions rather than occupational knowledge in context
0	0	No creditworthy material as described in bands 3 to 1.

Indicative content:

- environmental factors like vibration, debris, dust, background light, temperature and humidity might affect measurement and need to be addressed
- any parts and measuring setup would need to soak after cleaning and deburring, so all specimens and equipment are at the same temperature
- general health and safety such as maintaining a clean dry floor and clear walkways to prevent slips, trips and falls should be discussed, as well as the working environment, should display screen equipment (DSE) be used
- specific safety considerations, such as the sharp nature of the parts and much of the equipment
- back lighting and excess heat or cold to be avoided
- students to show awareness of different pieces of equipment available for measurement and the strengths and limitations of their selection
- the critical features to be inspected to ±0.01 mm are the shank diameter at 5.05 mm, the shank parallelism, the bobbin diameters 7.85 mm and the surface finish of 0.8 µm. These tend to be indicated by the number of

decimal places and accuracy of dimension. The remaining features are at a general tolerance of ±0.10 mm. The student should decide how many times they sample a dimension to reduce uncertainty. Some features require far more than 2x sampling to determine taper and out of round faults. Students need to be aware that some pieces of equipment do not meet specific uncertainty ratio for tight tolerances

- accurate drawing and geometric dimensioning and tolerance interpretation
- creation of a plan/working instruction for equipment and measurement
- uncertainty of equipment and budget calculations included (no measurement is complete without an uncertainty evaluation)
- reference to repeatability, calibration and tractability in measurement activity, such as:
    - measurement repeatability, uncertainty and minimum number of measurements for each dimension for each item, for example, is it planned to take one linear measurement across the diameters, or 2, or several, or a proposal to record the min/max or both measurements
    - to include sampling methods, number of samples, equipment used, how each piece of equipment is calibrated and how to overcome environmental factors. This must be completed for all features
    - risks include, for example, using safe practices for handling of equipment, removing trip hazards, orderly setup of workstations
- the plan clearly explains the processes used, for example, without reference to other sources, and can be used reliably to replicate the measurement
- use of comparisons as the basis for their justifications, for example, I have selected equipment X because it has a lower uncertainty than equipment Y

Content mapping:

K1.1: The concept of measurement

K1.2: How metrology is defined

K1.4: The definition of measurement standards

K1.5: The use of measurement standards in the calibration of measuring equipment when planning scientific measurements

K1.6: How the accuracy of measurements is related

K1.7: The concept and purpose of measurement uncertainty

K1.8: The different ways sources of uncertainty may be categorised

K1.9: The difference between repeatability and reproducibility of measurement results

K1.10: The concept of type A and type B evaluations of uncertainty

K1.12: How to mitigate for type A and type B effects (for example, using best practice for the measurement system to minimise uncertainty)

K1.13: The role of measurement uncertainty in conformity assessment

K1.14: The concept of confidence level using K = 1 (≈68%), K = 2 (≈95%) and K = 3 (≈99.7%)

K1.15: How an unbroken chain of comparisons, directly related to SI units, ensures confidence in results

K1.16: The links within a traceability chain

K1.18: The purpose of measurement instruments

K1.19: The differences between automated and manual measuring instruments

K1.20: How to apply best practice principles in measurement

K1.21: The purpose of an uncertainty budget

K1.22: The components of an uncertainty budget, used to calculate measurement uncertainty

K1.23: Factors that may influence the number of repeated measurements in a measurement task

K1.24: Factors that may influence the sampling strategy

K1.26: The correct terminology for measurement in metrology

K1.27: The impact of using incorrect terminology when communicating about measurement

K1.28: The sources which may be used to calculate maximum permissible error (MPE) of a system

K1.30: The tools and equipment (and software programs where applicable) and how these are used within the operating principles

K1.31: The considerations when deciding on the most appropriate equipment and tools to be used

K1.32: The advantages and limitations of different commercially available equipment and instrumentation used

K1.33: Why different sample preparation methods are required when preparing an item for measurement

K1.35: The purpose of planning a task in metrology

K1.36: How environmental conditions such as temperature, vibration, humidity and lighting can affect both the measuring equipment and the item to be measured, and consequently the data collected

K1.37: General approaches to dealing with environmental conditions

K1.41: The considerations to make when interpreting customer requirements

K1.42: How to mitigate risk, using control measures

K1.43: The hierarchy of written standards and their application in a metrology environment

K1.44: The importance of following SOPs when carrying out measurement tasks

K1.45: The importance of quality requirements within the workplace

S1.48: Make informed decisions about the needs of the measurement task

S1.49: Determine the design of the measurement plan

S1.50: Read a simple uncertainty budget for a measurement task and use it

S1.51: Use the correct terminology for measurement in metrology

S1.53: Select appropriate tools/equipment/instrumentation (with any associated software) when planning for a specific measurement task

S1.54: Provide reasoned decisions for the selection of equipment and instrumentation when planning a measurement task

S1.55: Plan any specific preparation tasks needed on the item to be measured

S1.57: Create a measurement

S1.58: Plan and record how to deal with potential environmental conditions

S1.61: Complete a risk assessment appropriate to the measurement task

S1.62: Document in the measurement plan the SOPs that should be followed during the measurement task, including those relevant to safe working practices (for example, handling of tools, equipment, instrumentation and software programs)

S1.63: Identify relevant regulatory procedures and standards required for the measurement task

S1.64: Document in the measurement plan the ISO standards and the specific quality requirements needed for the measurement task

Task 2

Assessor observation checklist

PO2 and PO4

Criteria	**Essential criteria** (all essential criteria must be awarded to pass)	**Assessor check**	**Marks awarded**
Workspace is organised prior to the start of any measurement; this includes collecting any equipment planned to be used, all samples and any other equipment required	No		1 mark
Cleaning of any sample parts	No		1 mark
Conducted any preparation tasks required for the measurement using the equipment available, for example, heat soak of machined components	No		1 mark
Used an inspection grade surface plate where applicable to the plan, and in a suitable environment	No		1 mark
Recorded their evaluation of available environment controls to control lighting, vibration, heat (20 ºC) and dust	No		1 mark
Taken suitable action to minimise any issues evident (including no action)	No		1 mark
Suitable equipment selected for accurate measurement of each key feature (guidance: suitable means suitable for the task)	Yes		1 mark

Criteria	**Essential criteria** (all essential criteria must be awarded to pass)	**Assessor check**	**Marks awarded**
Equipment used is examined and cleaned prior to measurement	No		1 mark
Equipment is calibrated and checked against zero and a suitable standard	No		1 mark for calibration 1 mark for checking against zero and a suitable standard (**maximum 2 marks**)
Equipment checked throughout the measurement to ensure regular calibration, and quarantine any unsuitable equipment	No		2 marks for consistent checks throughout 0 marks for any omission
All equipment has been calibrated before use against zero and a suitable standard (as applicable) Equipment is checked for calibration consistently, and all faults and errors corrected throughout	No		1 mark for calibration prior to use 1 mark for recalibration and correction of faults and errors (**maximum 2 marks**)
Conducted measurements of **each** feature using planned methods, maintaining the environment and safety as outlined in the plan	Yes		2 marks for each feature measured (**maximum 10 marks**) **Guidance:** there are 5 key features in the piece, 2 marks to be awarded for each feature
The measurement is undertaken with appropriate equipment and taken relevant care to avoid damage	Yes		1 mark
Ensuring manipulation of the equipment, touch and feel ensures the most accurate results	Yes		1 mark

Criteria	**Essential criteria** (all essential criteria must be awarded to pass)	**Assessor check**	**Marks awarded**
Exercise relevant care to ensure the equipment and specimens are not over handled to keep heat gain to a minimum	No		1 mark
Investigated all deviations to determine why results may have been inaccurate	No		2 marks
All samples repaired if possible, such as deburring Parts that are not possible to repair are suitably quarantined	Yes		1 mark
Correct procedure used when repairing any sample	Yes		1 mark
Suitable equipment selected for any repairs conducted	Yes		1 mark
Applied safe handling requirements for equipment, including the use of personal protective equipment if required	Yes		1 mark
Maintained health and safety of the workstation throughout, such as maintaining organisation of all equipment being used, safe use of any chemicals or electrical equipment, and appropriate handling of all equipment and tools	Yes		1 mark

Criteria	Essential criteria (all essential criteria must be awarded to pass)	Assessor check	Marks awarded
Cleaned up the workstation and appropriate surfaces following the completion of the inspection, returned all equipment to storage location, and disposed of any waste product appropriately	No		1 mark for cleaning workstation and surfaces 1 mark for return/storage of equipment used and/or any disposal of waste (**maximum 2 marks)**
Total marks			36 marks

Content mapping:

K2.1: The purpose of validation or verification techniques for measuring equipment

K2.2: The purpose of calibrating and testing metrology equipment

K2.3: How to check the current calibration status

K2.4: Why it is important to follow the correct escalation route if an instrument's calibration status is not identifiable, or if the instrument is clearly out of calibration

K2.5: The escalation route if the calibration status is not identifiable, or if the instrument is clearly out of calibration

K4.1: How to recognise when measuring equipment is operating incorrectly

K4.2: The employees' responsibilities when an anomaly in the measurement process has been identified

K4.3: How repairs on measuring equipment are carried out

S2.6: Prepare the work environment in order to perform measurement tasks

S2.7: Set up the equipment and the item to be measured

S2.8: Read and follow a calibration procedure

S2.9: Determine the current calibration status of a system to ensure the equipment is at the required level of accuracy

S2.10: Select/prepare the correct reference material/standard for the measurement task

S2.11: Perform a measurement task using a developed plan

S4.4: Use problem solving techniques to identify issues relating to measuring equipment

S4.6: Source expert help from senior colleagues or others on metrology issues

S4.7: Follow the process for basic repairs on measurement equipment

Task 3

PO3 and PO4

Band	Mark	Descriptor
3	7–9	The student has: • prepared a report that evaluates the ability of the machine to produce parts consistently within tolerances • used the relevant data to inform key statements made in the report • explained the data in detail, including root causes of any errors, all of which is accurate and supports the evaluation • explained any errors encountered in the process, giving good reasons why these may have occurred • given realistic and justified recommendations on how to improve the production process and the measurement process undertaken in task 2
2	4–6	The student has: • prepared a report that explains the ability of the machine to produce parts consistently within tolerances • used some key data to inform the key statements made in the report, although the data may not fully support reasoning • presented and described data accurately which supports the explanation overall • described the errors faced, giving some detail about why these may have occurred, that has some relevance • described some relevant recommendations on how to improve the production process and the measurement process undertaken in task 2
1	1–3	The student has: • prepared a report that identifies to some extent the ability of the machine to produce parts consistently within tolerances • presented some key data, although the data may be unsupported by clear reasoning or explanation, and the accuracy of the data is inconsistent • attempted suggestions on improving process with some but limited relevance or realism
0	0	No creditworthy material as described in bands 3 to 1.

PO3 and PO4

Criteria	Marks
Title is clear and accurate and all axis correctly labelled (0 marks if 1 or more is missing or incorrect)	1 per graph/feature (3) **(maximum 3 marks)**
Mean and mode correctly calculated (0 marks if 1 or more **is** missing or incorrect)	1 per graph/feature (3) **(maximum 3 marks)**
Mean and mode correctly indicated on the relevant normal distribution curve	1 per graph/feature (3) **(maximum 3 marks)**
Calculated the standard deviation for each set, showing the calculation on the notes for the graph (1 mark each for correct calculation and correct plotting)	2 per graph/feature (3) **(maximum 6 marks)**
Indicated on the graph 1, 2 and 3 sigma, 3 x SD either side of the mean	1 per graph/feature (3) **(maximum 3 marks)**
Plotted the normal distribution curve for every set of data, for each feature on suitable graph paper showing the nominal size (such as size on the drawing) with no anomalous results presented in the graphs Where the graphs are producing strange or anomalous results, these results are set aside and reported on as an error	3 per graph/feature (3) **(maximum 9 marks)**
Each graph is supported by a table of all results for each feature	1 per graph/feature (3) **(maximum 3 marks)**
Total marks	30

Indicative content:

- a clean, clear set of graphs indicating mode, mean and 1, 2 and 3 sigma and notes for each of the features, including taper as well as diameter of the shank, and good discussion on the suitability of the production method for the data available
- the student uses their previously recorded data to calculate the mean, mode and SD for each set. Using suitable graph paper, they will draw the normal distribution curve for each dimensional set and indicate the 6 SD (1, 2 and 3 sigma), 3 either side of the nominal size
- the student discusses, in writing, the accuracy range produced, the uncertainties in the measuring process and the suitability of the machine against the tolerance given on the drawing or in the standard for the part (to be presented as part of a report)

Content mapping:

K3.1: The stages of processing raw data

K3.2: The purpose of the following techniques to remove spurious results from metrology data

K3.3: Why the following are used to interrogate and critically analyse measurement data

K3.4: How to review the measurement data obtained against measurement requirements

S1.65: Use feedback to develop and improve

S3.5: Use digital technology to process raw data and record measurement results in line with specifications

S3.6: Identify patterns in collected data

S3.7: Assess repeatability and reproducibility of measurements to determine any variation within the data, and establish a degree of confidence

S3.8: Interrogate and critically analyse measurement data to identify any anomalous results

S3.9: Re-run investigations to assess invalid data

S3.10: Contribute to the production of reports and other measurement documentation

S3.11: Present data/results in the most appropriate format to meet customer requirements (for example, production of reports and other measurement documentation)

Performance outcome grid

Task	PO1	PO2	PO3	PO4	Total
1	27	2	0	0	29
2	0	26	0	10	36
3	0	0	29	10	39
Total marks	27	28	29	20	104
% weighting	25.96%	26.92%	27.88%	19.23%	99.9%

Document information

The T Level Technical Qualification is a qualification approved and managed by the Institute for Apprenticeships and Technical Education.

Owner: Head of Assessment Design

Change History Record

Version	Description of change	Approval	Date of Issue
v1.0	Post approval, updated for publication.		January 2021
v1.1	Post approval amendments (Institute reference: ODSR_S_012 - ODSR_S_014)		March 2021
v1.2	NCFE rebrand.		September 2021
v1.3	Sample added as a watermark	November 2023	21 November 2023