T Level Technical Qualification in Science

Occupational specialism assessment (OSA)

Metrology Sciences

Assignment 2 - Distinction

Guide standard exemplification materials

T Level Technical Qualification in Science

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Guide standard exemplification materials

Metrology Sciences

Assignment 2

Contents

Introduction

The material within this document relates to the Metrology Sciences occupational specialism sample assessment. These exemplification materials are designed to give providers and students an indication of what would be expected for the lowest level of attainment required to achieve a pass or distinction grade.

The examiner commentary is provided to detail the judgements examiners will undertake when examining the student work. This is not intended to replace the information within the qualification specification and providers must refer to this for the content.

In assignment 2, the student must write a measurement plan, undertake the measurement of sample parts and analyse the results

After each live assessment series, authentic student evidence will be published with examiner commentary across the range of achievement.

Assignment 2

Task 1 – writing a metrology plan

Scenario

The company you work for need to produce large volumes of simple steel machined parts, produced by CNC turning machines. They operate a Six Sigma lean manufacturing system and are testing CNC machining centres using statistical process control to establish which machines are compliant for these parts. The parts are tensile test specimens to BS EN ISO 6892 for Hounsfield/TQ tensometers.

You will be provided with a sample (minimum 25) of 100 parts from a production run on the same machine using the same materials and tooling. All measurements are in millimetres.

Task

From the above drawing, create a working instruction detailing your plan. Your plan should include:

- how you will inspect every critical feature
- your sampling method to ensure all aspects are recorded
- the data collection method selected
- creation of a suitable uncertainty budget
- how you will ensure calibration of equipment selected
- appropriate tooling and equipment selection, with justification, taking into consideration the relative uncertainty of measurement of the equipment selected for each measurement
- how you will ensure environmental factors are dealt with
- how you will be minimising the impact of hazards and complying with relevant health and safety, law and legislation
- any other relevant inclusions

Student evidence

For the inspection of the part, I will undertake different processes for the measurement of each of the critical features. This is because measurement equipment is suitable for certain applications because some equipment will produce less uncertainty than others.

I will check each measurement on each critical feature 3 times. This is because if a mistake in a measurement is made then doing it 3 times should identify if any mistakes have been made. If I made 1 measurement, then a mistake could be made, and it would be completely unnoticed. If I made 2 measurements and they did not agree then I would not know which one is correct. But taking 3 measurements, if 2 results agree and 1 doesn't then it is most likely that the 1 measurement which does not agree would be wrong.

Below is a table for how I will inspect each critical feature.

Measurement Value	What critical feature does this measurement relate to?	How important is this measurement?	Tool to measure this critical feature	How will the tool be used	Uncertainty of the measurement
7.85	Bobbin diameter	Very important based on the number of decimal places on the drawing	A micrometer or vernier calliper could be used to measure the diameter. However, a micrometer is more accurate so this will be used	The bobbin diameter will be placed inside the micrometer. The micrometer will be then tightened until the thimble clicks. This makes sure that the micrometer is not overtightened	Low
5.05	Shank diameter	Very important based on the number of decimal places on the drawing	A micrometer or vernier calliper could be used to measure the diameter. However, a micrometer is more accurate so this will be used	The bobbin diameter will be placed inside the micrometer. The micrometer will be then tightened until the thimble clicks. This makes sure that the micrometer is not overtightened	Low

25	Shank length	There are no decimal places so this length is less important	Vernier callipers	This measurement is very difficult to attain accurately. This is because this length is between the bottom of each fillet radius and it is very difficult for the user to identify where the radius meets the shank	High
5	Bobbin length	There are no decimal places so this length is less important	Vernier callipers	Vernier callipers would be placed on the flat end of the bobbin and the top of the radius. This would be difficult to measure accurately as the user may not be able to place the vernier calliper exactly on the top of the radius	Medium
Radius	Radius between bobbin and shank	There is no number assigned to this	Radius gauge if a number was given on the drawing. Visual inspection to check radius is present if no number is provided	A radius gauge would be used to check the radius. Because the radius is not dimensioned then the user would just check that the radius is present	Medium

Uncertainty is the doubt that exists for each measurement. When completing an uncertainty calculation, we quantify the amount of doubt in the measurement.

In these measurements there is uncertainty due to the measurement tool, the environment and the operator skill.

There are 2 ways to estimate the uncertainties. These are:

- type A evaluations - uncertainty measurements using statistics
- type B evaluations - uncertainty measurements from other information such as previous experience

I think that type A evaluations are much more suitable for calculating the uncertainty budget.

To reduce the uncertainty in the equipment used I would make sure that it has an up-to-date calibration certificate. Also, I would ensure that the temperature of the workshop was stable, or I would use a heat plate or soak to make sure the sample is at a consistent temperature if it is too hard to control the temperature of the whole room. This is because the size of the material will change very slightly with changes in temperature due to thermal expansion of the material. To prevent this, I will make sure that the air conditioning in the workshop is set to 20 degrees and that no windows are opened. There are no issues with over manipulation affecting the results because the piece or the equipment does not have tolerances that are so fine they are affected by the small expansions in the heat exchange through touch, unless I hold them for an extreme amount of time.

As I will be working in the workshop I will have to comply with all relevant health and safety. I will follow the risk assessment for the workshop. To minimise the risk of tripping I will make sure that when not using inspection equipment that I store it safety and orderly, therefore reducing the risks of tripping.

Task 2 – conducting metrology measurements and basic repairs

Scenario

Your plan has been accepted by the company and is now used as the working instructions for measuring these parts. You have received the first batch of manufactured components to measure.

Task

Measure a sample (minimum 25) of the 100 parts supplied, using one of the methods planned.

Record all results in a suitable format.

Repair all possible errors or damage in equipment and produced parts.

While undertaking the measurement of each part, you should ensure the accuracy of your instruments by checking, maintaining, repairing and recalibrating them as you proceed.

Errors, faults and breakages beyond the reasonable expertise of the operator to repair or otherwise beyond SOPs should be quarantined as per company policy.

You must complete the following:

- prepare your sample and tooling appropriately
- maintain equipment throughout the process
- record all data making notes as appropriate, especially if you need to undertake unplanned activity
- update the plan if additional activity is required
- quarantine or disposal of faulty equipment beyond your scope

Student evidence

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	Workplace was suitably organised prior to the start of the assessment, showing effective planning	1 mark 1 awarded
Cleaning of any sample parts	No	All sample parts were cleaned effectively using the correct procedure	1 mark 1 awarded
Conducted any preparation tasks required for the measurement using the equipment available, for example, heat soak of machined components	No	All parts were suitably prepared prior to measurement	1 mark 1 awarded
Used an inspection grade surface plate where applicable to the plan, and in a suitable environment	No	The correct surface plate was used to prepare the sample parts for inspection and measurement	1 mark 1 awarded
Recorded their evaluation of available environment controls to control lighting, vibration, heat (20 ºC) and dust	No	No recording of the evaluation of environment controls is evident, although appropriate action has been taken to minimise some issues	1 mark 0 awarded
Taken suitable action to minimise any issues evident (including no action)	No	Some action has been taken to minimise lighting issues, vibration, and heat	1 mark 1 awarded

Criteria	**Essential criteria** (all essential criteria must be awarded to pass)	**Assessor check**	**Marks awarded**
Suitable equipment selected for accurate measurement of each key feature (guidance: suitable means suitable for the task)	Yes	Suitable equipment has been selected for each feature to be measured	1 mark 1 awarded
Equipment used is examined and cleaned prior to measurement	No	Equipment has been suitably and accurately examined and cleaned prior to measurement	1 mark 1 awarded
Equipment is calibrated and checked against zero and a suitable standard	No	Equipment was calibrated and checked against a higher standard	1 mark for calibration 1 mark for checking against zero and a suitable standard (**maximum 2 marks**) 2 awarded
Equipment checked throughout the measurement to ensure regular calibration, and quarantine any unsuitable equipment	No	Equipment was checked during the measurement but that was too infrequent to be awarded any additional marks	2 marks for consistent checks throughout 0 marks for any omission 0 awarded
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	Equipment was calibrated before the measurement process, however no recalibration was done during the measurement	1 mark for calibration prior to use 1 mark for recalibration and correction of faults and errors (**maximum 2 marks**) 1 awarded

Criteria	**Essential criteria** (all essential criteria must be awarded to pass)	**Assessor check**	**Marks awarded**
Conducted measurements of **each** feature using planned methods, maintaining the environment and safety as outlined in the plan	Yes	Each feature was correctly measured, while maintaining the environment suitably	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 10 awarded
The measurement is undertaken with appropriate equipment and taken relevant care to avoid damage	Yes	Appropriate care was taken throughout to avoid damage or injury	1 mark 1 awarded
Ensuring manipulation of the equipment, touch and feel ensures the most accurate results	Yes	Touch, feel and equipment manipulation was used to ensure reliable results throughout	1 mark 1 awarded
Exercise relevant care to ensure the equipment and specimens are not over handled to keep heat gain to a minimum	No	A thorough inspection of each sample piece was taken, which often led to over-handling. Although this will not effect the results for this part, it may for future parts	1 mark 0 awarded
Investigated all deviations to determine why results may have been inaccurate	No	Some re-measurement was taken if any inaccuracies were found, but this is the only investigation into deviations, which isn't sufficient to be awarded the marks	2 marks 0 awarded
All samples repaired if possible, such as deburring Parts that are not possible to repair are suitably quarantined	Yes	All repairs were conducted when possible and quarantined if not able	1 mark 1 awarded

Criteria	**Essential criteria** (all essential criteria must be awarded to pass)	**Assessor check**	**Marks awarded**
Correct procedure used when repairing any sample	Yes	Correct procedure used throughout the repair process	1 mark 1 awarded
Suitable equipment selected for any repairs conducted	Yes	Correct equipment was selected depending upon the repair	1 mark 1 awarded
Applied safe handling requirements for equipment, including the use of personal protective equipment if required	Yes	Correct handling procedures followed throughout the process and the correct protective equipment used, depending upon the specific activity for example, eye protection for deburring	1 mark 1 awarded
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	Health and safety precautions were followed consistently throughout the task	1 mark 1 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	The student organised the workstation, but did not return the equipment to its original location or clean down the workstations and surfaces following the activity	1 mark for cleaning workstation and surfaces 1 mark for return/storage of equipment used and/or any disposal of waste (**maximum 2 marks)** 0 awarded
Total marks			36 marks 27 awarded

Task 3 - interpreting metrology measurement results

Scenario

You have completed the inspection of a sample of manufactured components. You must report on your findings to provide feedback on the current manufacturing process.

Task

Using the data sets created and tabulated from task 2, you should select 3 key features. For each of these features you must complete the following:

- determine the mean, mode and the standard deviation (SD) for each selected feature
- plot the standard bell curve normal distribution for each selected feature
- determine the six SD (1, 2, and 3 sigma) tolerance for each selected feature

Produce a report on the capability of the production method based on all of your results from task 2.
Your report should include:

- key data relating to accuracy of the machining process
- any errors encountered
- any recommendations for future improvement in the process, that will help increase the accuracy of the results, with justification
- any other relevant inclusions

Student evidence

For this task I am investigating the shank diameter, bobbin diameter and bobbin length. The table below shows the results from my inspection. The table shows that there is variation in the values. I will create normal distribution graphs as these show the distribution of the lengths/diameters about the mean length/diameters.

The standard deviation is a measure of spread and shows how spread out the data is. For an unoptimised process the bell curve would be very wide meaning that there is a lot of deviation from the mean. For an optimised process, the bell curve would be very thin meaning that there is little deviation from the mean. There will always be variation in part sizes, even if we try to make them all exactly the same. If the process is really accurate then we might have to complete finer measurements with more decimal places to establish the differences.

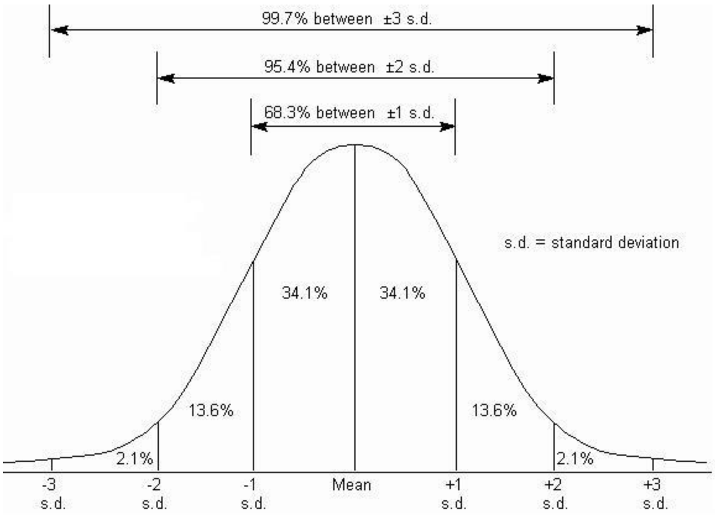
This data was grouped to calculate the mean and the standard deviation. This is because there were multiple parts with the same lengths. Therefore, I used the following formulae below.

$$Mean = \frac{\sum fx}{\sum f}$$

$$Standard\ Deviation = \sqrt{\frac{\sum fx^2}{\sum f} - \left(\frac{\sum fx}{\sum f}\right)^2}$$

Part Number	Bobbin Diameter	Shank Diameter	Bobbin Length
1	7.85	5.04	4.99
2	7.87	5.03	5
3	7.81	5.02	5
4	7.84	5.06	5
5	7.83	5.06	5.02
6	7.86	5.05	5.02
7	7.87	5.09	5.02
8	7.84	5.07	5.03
9	7.85	5.07	4.99
10	7.84	5.06	5.02
11	7.86	5.06	4.95
12	7.82	5.04	4.97
13	7.82	5.06	4.98
14	7.81	5.05	4.99
15	7.85	5.03	4.98
16	7.89	5.06	4.98
17	7.84	5.06	5.03
18	7.83	5.05	5.03
19	7.83	5.03	5.04
20	7.87	5.04	5.01
21	7.87	5.09	5
22	7.83	5.04	5
23	7.86	5.06	5.01
24	7.85	5.06	4.98
25	7.86	5.02	4.99

The normal distribution curve below shows how we expect the samples to vary. We expect that 68.3% of the parts are within one standard deviation above or below the mean. We expect that 95.4% of the parts are within 2 standard deviations above or below the mean. We expect that 99.7% of the parts are within 3 standard deviations above or below the mean.



The tolerance of a part are the acceptance limits. There were no tolerances provided but if, for example, the tolerance is 7.85mm +-0.01mm then any part above 7.86mm and below 7.84mm could not be accepted. Making the tolerance band wider means that more parts will fit within the tolerance.

These errors may have come about due to incorrect measurement and could be a result of environmental factors such as temperature. Alternatively, these errors may have come about due to problems with the machining process. This could include vibration, tool wear or inconsistency with how the part is clamped in the machining operation.

The process of manufacturing the parts could be improved by monitoring tool wear and replacing the tool before the part quality is reduced. It would be a good idea if the parts were inspected on the line so that machine adjustments can be made at the time, preventing large batches of inadequate parts being produced.

The following pages show the calculations necessary to produce the normal distribution graphs.

x	frequency	fx	fx^2
7.81	2	15.62	121.9922
7.82	2	15.64	122.3048
7.83	3	23.49	183.9267
7.84	5	39.2	307.328
7.85	4	31.4	246.49
7.86	4	31.44	247.1184
7.87	4	31.48	247.7476
7.89	1	7.89	62.2521
SUM	25	196.16	1539.1598

<u>Bobbin Diameter</u>

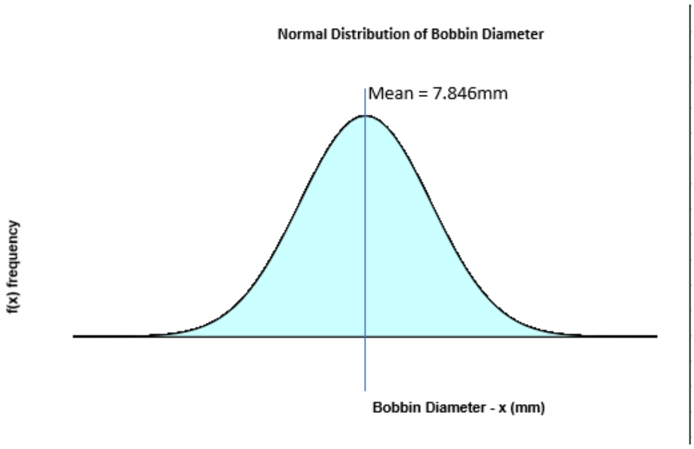
$$Mean = \frac{\sum fx}{\sum f} = \frac{196.15}{25} = 7.8464mm$$

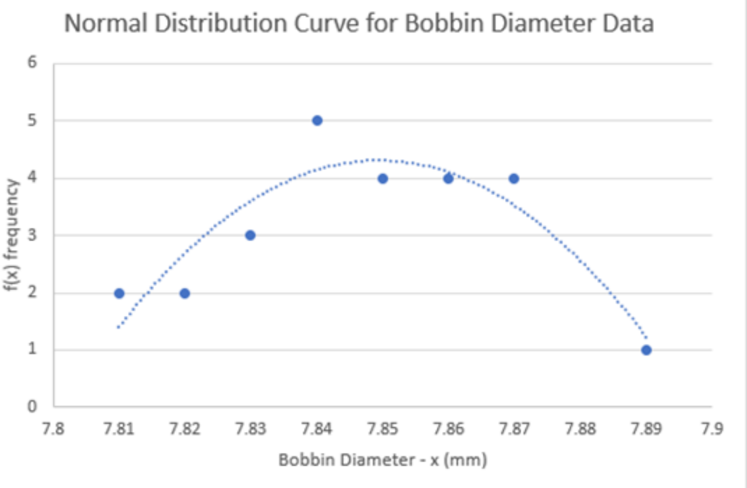
$$Standard\ Deviation = \sqrt{\frac{\sum fx^2}{\sum f} - \left(\frac{\sum fx}{\sum f}\right)^2} =$$

$$\sqrt{\frac{1539.0031}{25} - \left(\frac{196.15}{25}\right)^2} = 0.01998 \text{ mm}$$

Mean - 3 Standard Deviation	7.786472
Mean - 2 Standard Deviation	7.806448
Mean - 1 Standard Deviation	7.826424
Mean + 1 Standard Deviation	7.866376
Mean + 2 Standard Deviation	7.886352
Mean + 3 Standard Deviation	7.906328

Mode = 7.84mm





<u>Shank Diameter</u>

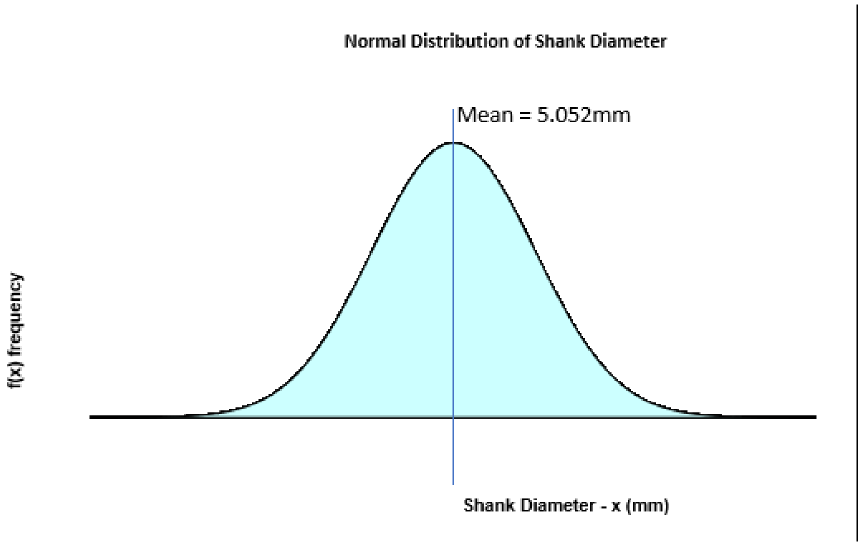
x	frequency	fx	fx^2
5.02	2	10.04	50.4008
5.03	3	15.09	75.9027
5.04	4	20.16	101.6064
5.05	3	15.15	76.5075
5.06	9	45.54	230.4324
5.07	2	10.14	51.4098
5.09	2	10.18	51.8162
SUM	25	126.3	638.0758

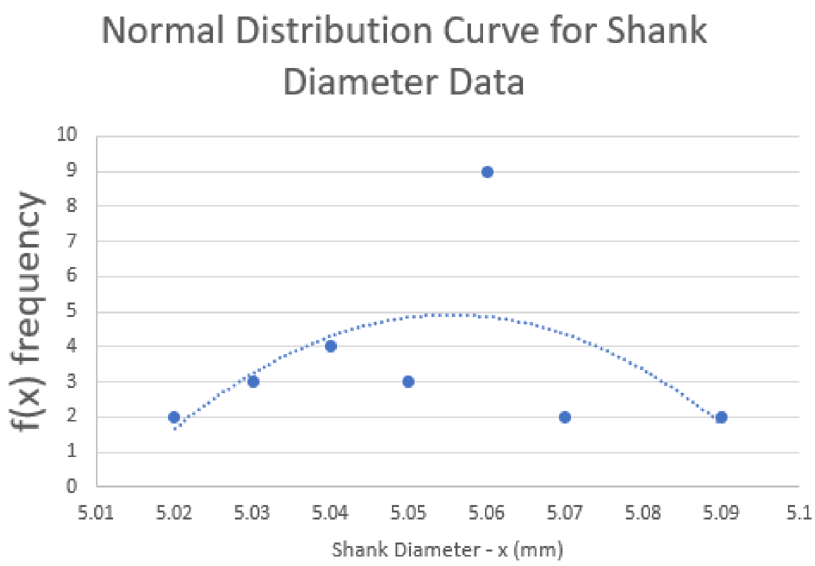
$$Mean = \frac{\sum fx}{\sum f} = \frac{126.3}{25} = 5.052mm$$

$$Standard\ Deviation = \sqrt{\frac{\sum fx^2}{\sum f} - \left(\frac{\sum fx}{\sum f}\right)^2} = \sqrt{\frac{638.0758}{25} - \left(\frac{126.3}{25}\right)^2} = 0.0181 \text{ mm}$$

Mean - 3 Standard Deviation	4.9976677
Mean - 2 Standard Deviation	5.0157785
Mean - 1 Standard Deviation	5.0338892
Mean + 1 Standard Deviation	5.0701108
Mean + 2 Standard Deviation	5.0882215
Mean + 3 Standard Deviation	5.1063323

Mode = 5.06mm





Bobbin Length

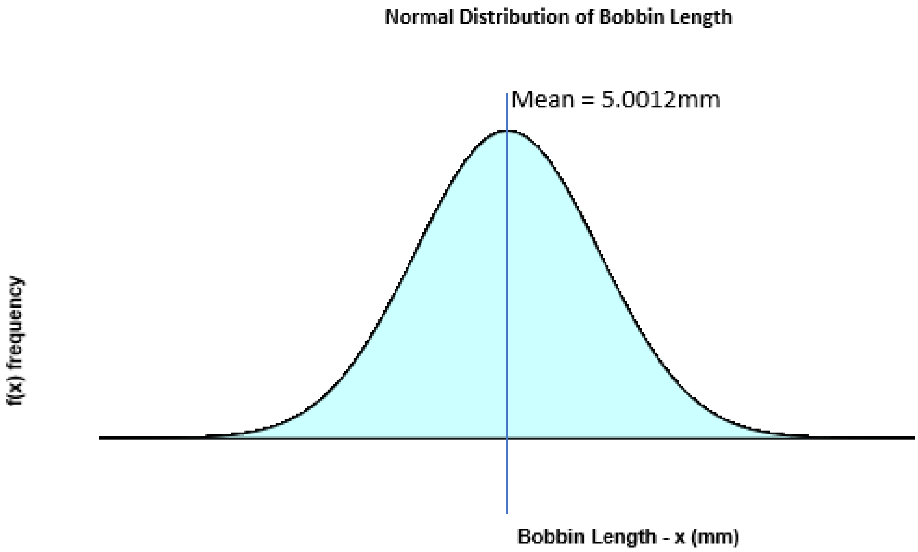
x	frequency	fx	fx^2
4.95	1	4.95	24.5025
4.97	1	4.97	24.7009
4.98	4	19.92	99.2016
4.99	4	19.96	99.6004
5	5	25	125
5.01	2	10.02	50.2002
5.02	4	20.08	100.8016
5.03	3	15.09	75.9027
5.04	1	5.04	25.4016
SUM	25	125.03	625.3115

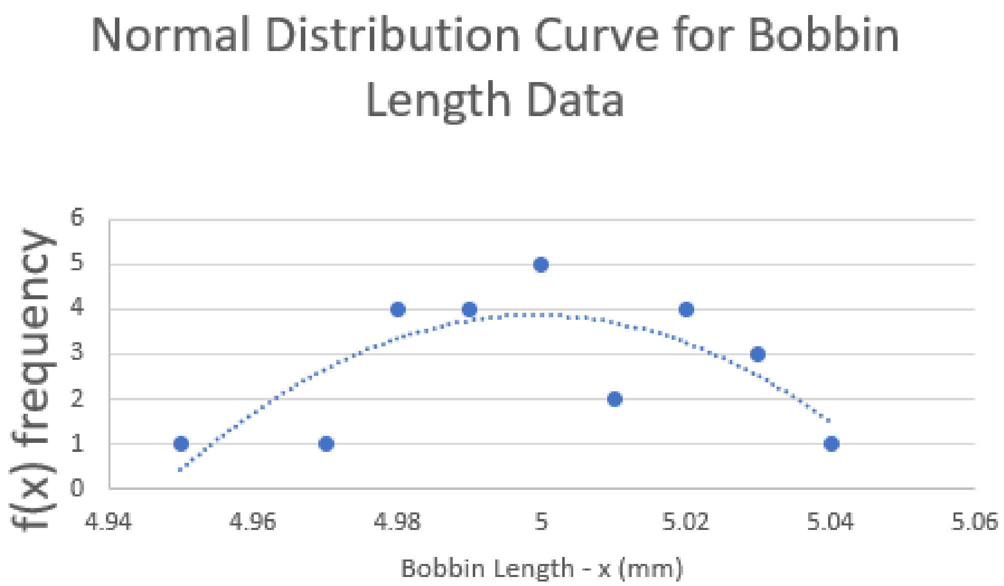
$$Mean = \frac{\sum fx}{\sum f} = \frac{125.03}{25} = 5.001mm$$

$$Standard\ Deviation = \sqrt{\frac{\sum fx^2}{\sum f} - \left(\frac{\sum fx}{\sum f}\right)^2} = \sqrt{\frac{625.3115}{25} - \left(\frac{125.03}{25}\right)^2} = 0.02141 \text{ mm}$$

Mode = 5mm

Mean - 3 Standard Deviation	4.936958
Mean - 2 Standard Deviation	4.958372
Mean - 1 Standard Deviation	4.979786
Mean + 1 Standard Deviation	5.022614
Mean + 2 Standard Deviation	5.044028
Mean + 3 Standard Deviation	5.065442




Normal Distribution Curve for Bobbin Length Data
f(x) frequency
0
1
2
3
4
5
6
4.94
4.96
4.98
5
5.02
5.04
5.06
Bobbin Length - x (mm)

Examiner commentary

The student has completed a very detailed plan which provides very detailed information relating to the needs of the brief and is presented in a very logical format. The plan demonstrates extensive metrological understanding of approaches associated with basic measurement tasks.

The plan produced by the student outlines the key equipment planned to be used, considering the importance of the feature, the accuracy and performance of the equipment and the uncertainty of the measurement caused by the selected measuring equipment.

During the practical task, the student demonstrated good measurement skills and carried out the measurements confidently and accurately. The student utilised information from a range of appropriate sources to form a plan and consider uncertainty. Correct techniques have been reflected throughout the practical and any problems were tackled effectively through analysis to find a suitable solution.

The student checked all equipment thoroughly before the measurement of the features took place, this included a visual inspection for overall condition, as well as checking the equipment for calibration and accuracy against a suitable standard.

The student recorded and rectified inaccuracies in measurement, investigating the reasons for the initial inaccuracy.

The student thoroughly examined metrological data and presented data in a suitable and accurate format consistently, which demonstrates the key skills for the sector. The data has then been applied critically to analyse the outcome of the practical task to provide recommendations for future improvement, giving concise explanations throughout.

The data provided by the student is accurate and presented in a clear format. The student has understood and presented graphs clearly and accurately, and calculated standard deviation accurately and consistently, throughout. All data presented by the learner is done so in a suitable format, with a range of suitable charts and tables included which contain all of the required information.

The student applied a range of presentation methods to demonstrate all of the critical information around the three selected key features, including as a table of results, SD calculation, SD plotting and mean calculation. The supporting report is precise and clear, analysing the results, using well supported judgements.

Overall grade descriptors

The performance outcomes form the basis of the overall grading descriptors for pass and distinction grades.

These grading descriptors have been developed to reflect the appropriate level of demand for students of other level 3 qualifications, the threshold competence requirements of the role and have been validated with employers within the sector to describe achievement appropriate to the role.

Occupational specialism overall grade descriptors:

Grade	Demonstration of attainment
Pass	The evidence is logical but displays minimal knowledge of basic metrological content in response to the demands of the brief.
	The student makes some use of relevant knowledge and understanding of how metrology informs practices in many sectors and demonstrates a limited understanding of perspectives or approaches associated with basic measurement tasks and principles.
	The student makes adequate use of facts/theories/approaches/concepts and attempts to demonstrate breadth and depth of metrological knowledge and understanding.
	The student is able to identify some metrological information from appropriate sources and makes use of appropriate information/appraise relevancy of information and can combine information to make decisions.
	The student makes minimal judgements/takes appropriate action/seeks clarification with metrological sources of guidance and is able to make limited progress towards solving non-routine problems in real life measurement activities/situations.
	The student attempts to demonstrate metrological skills and knowledge of the relevant concepts and techniques reflected in a measurement services role and generally applies this across different contexts and measurement skill sets.
	The student shows adequate understanding of unstructured measurement-related problems that have not been seen before, using limited knowledge to find solutions to problems and make justification for strategies for solving problems, explaining their reasoning.
Distinction	The metrological evidence is precise, logical and provides a detailed and informative response to the measurement related demands of the brief.
	The student makes extensive use of relevant knowledge and understanding of how metrology informs practices in many sectors and demonstrates an understanding of perspectives or approaches associated with basic measurement tasks and principles.

	The student makes decisive use of facts/theories/approaches demonstrating extensive breadth and depth of metrological knowledge/understanding and selects highly appropriate skills/techniques/methods.
	The student is able to comprehensively identify metrological information from a range of suitable sources and makes exceptional use of appropriate information/appraise relevancy of information and can combine information to make coherent measurement decisions.
	The student makes well founded judgements/takes appropriate action/seeks clarification with metrological sources of guidance and is able to use that to reflect on real life measurement activities/situations.
	The student demonstrates extensive metrological skills and knowledge of the relevant concepts and techniques reflected in a measurement services role and precisely applies this across a variety of contexts and tackles unstructured problems that have not been seen before, using their knowledge and measurement skill sets to analyse and find suitable solutions to the measurement problems.
	The student can thoroughly examine metrological data/information in context and apply appropriate analysis in confirming or refuting conclusions and carrying out further work to justify strategies for solving problems, giving concise explanations for their reasoning.

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	Published final version.		June 2021
v1.1	NCFE rebrand		September 2021