

2.2 Manufacture: tolerances, variation and inspection

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS tolerance • clearance

Objective

Manufacture: tolerances, variation and inspection. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

■ What would explain this observation?

- Two parts can each match a nominal drawing yet fail to assemble if allowed variation has not been considered. Manufacture produces a range of dimensions.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- A **tolerance** specifies an allowed dimensional range around or beside a nominal value. Precision concerns consistency of repeated measurements or production, while accuracy concerns agreement with a reference. Process selection must consider material, geometry, quantity, surface finish, waste and achievable variation rather than appearance alone.
- tolerance: The allowed range of variation in a specified dimension; **clearance** : The dimensional space between mating parts under the stated model.



■ Choose evidence that can test it

- For a worst-case clearance model, subtract the largest shaft from the smallest hole for minimum clearance, and the smallest shaft from the largest hole for maximum clearance. The calculation assumes the stated dimensional limits and ideal geometry. Shape, alignment, temperature and measurement uncertainty can affect actual assembly.
- Use safe school-made models or a provided dimension dataset. Specify dimension units, nominal values and limits before testing. Measure with an appropriate calibrated instrument at agreed positions, record every result and classify against the specified range. Retain rejected pieces and explain whether the problem concerns the design limits, process variation or measurement method.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: a hole is 10.0 ± 0.2 mm, giving 9.8–10.2 mm; a shaft is 9.5 ± 0.1 mm, giving 9.4–9.6 mm. Minimum clearance is $9.8 - 9.6 = 0.2$ mm and maximum is $10.2 - 9.4 = 0.8$ mm. This model predicts positive clearance across the stated limits. It does not establish strength or fitness for a safety-critical application.

Example:

A hole ranges from 12.0 to 12.4 mm and a shaft from 11.5 to 11.8 mm. Calculate minimum clearance. Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ Check the conclusion and its limits

- A tighter tolerance can increase cost, inspection time and waste, and may not improve the user outcome. A measuring instrument with a fine display does not automatically have the accuracy required to accept a part near its limit.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A finer instrument display guarantees sufficiently accurate dimensional inspection. This claim is false: A tighter tolerance can increase cost, inspection time and waste, and may not improve the user outcome. A measuring instrument with a fine display does not automatically have the accuracy required to accept a part near its limit.

Key:

Manufacture: tolerances, variation and inspection: For a worst-case clearance model, subtract the largest shaft from the smallest hole for minimum clearance, and the smallest shaft from the largest hole for maximum clearance. The calculation assumes the stated dimensional limits and ideal geometry. Shape, alignment, temperature and measurement uncertainty can affect actual assembly.

2 Practice

2.1 Which dimensions determine the minimum worst-case clearance? Choose one answer.

- **A** Smallest hole minus largest shaft
- **B** Largest hole minus smallest shaft
- **C** Nominal hole plus nominal shaft

[1]

2.2 A hole ranges from 12.0 to 12.4 mm and a shaft from 11.5 to 11.8 mm. Calculate minimum clearance. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: A finer instrument display guarantees sufficiently accurate dimensional inspection.

[2]

2.4 The allowed range of variation in a specified dimension: write the technical term. [1]

3 Exam-style questions

3.1 A hole is 10.0 ± 0.1 mm and a shaft 9.9 ± 0.2 mm. Find worst clearances and decide whether clearance is guaranteed. [4]

Solutions

2.1 A For a worst-case clearance model, subtract the largest shaft from the smallest hole for minimum clearance, and the smallest shaft from the largest hole for maximum clearance. The calculation assumes the stated dimensional limits and ideal geometry. Shape, alignment, temperature and measurement uncertainty can affect actual assembly.

2.2 minimum clearance=min hole–max shaft=12.0–11.8=0.2mm.

2.3 False. A tighter tolerance can increase cost, inspection time and waste, and may not improve the user outcome. A measuring instrument with a fine display does not automatically have the accuracy required to accept a part near its limit.

2.4 tolerance. tolerance means The allowed range of variation in a specified dimension.

3.1 Minimum 9.9–10.1=–0.2 mm; maximum 10.1–9.7=0.4 mm. Interference is possible. Nominal clearance does not guarantee fit or certify strength.