1.10 Tolerances and Quality Control

AQA 8552 · Calculator allowed · about 45 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Show working for calculations. Unless stated otherwise, all stated tolerance limits are inclusive. Use the units given and distinguish a result for an inspected sample from a claim about every unit. Credit equivalent valid calculation methods and justified inspection or process improvements; award each distinct achievement only once.

1 A laser-cut acrylic panel has a slot specified as 20.0 mm ± 0.3 mm. Both tolerance limits are included. State the smallest and largest acceptable slot widths.

(Total for Question 1 is 2 marks)

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2 An injection-moulded clip thickness is specified as 2.40 mm ± 0.08 mm, inclusive. The current calliper reads to the nearest 0.1 mm. For this comparison, assume ideal rounding and no other measurement error. The table gives two actual thicknesses. State the acceptable range. Use the table to explain why the calliper cannot reliably distinguish conformity near a limit, and suggest a more suitable instrument and one check on its use.

Clip	Actual thickness (mm)
A	2.31
B	2.34

(Total for Question 2 is 4 marks)

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3 A batch of 200 birch-plywood panels has a width specification of 300 mm ± 1 mm, inclusive. A stratified sample of 20 panels from different positions in the batch gives the measurements below. State the acceptable range, calculate the sample defective percentage and recommend a next inspection step justified by this evidence and its limits.

Measured width (mm)	Number of sampled panels
298	1
299	4
300	10
301	4
302	1

(Total for Question 3 is 4 marks)

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4 A small workshop finds that laser-cut acrylic covers sometimes exceed a 100.0 mm ± 0.5 mm width limit (inclusive). Records show the errors cluster on one machine after its lens is changed. Propose a justified process improvement and a way to check whether it works, including how to treat boundary measurements.

(Total for Question 4 is 4 marks)

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5 A batch of aluminium pins has a diameter specification of 8.00 mm ± 0.05 mm, inclusive. The table records five inspected pins. State the acceptable range, identify each conforming measurement and state how many inspected pins fail.

Pin	Measured diameter (mm)
A	7.94
B	7.95
C	8.00
D	8.05
E	8.06

(Total for Question 5 is 3 marks)

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6 A plywood jig plate must be 120 mm ± 1 mm wide, inclusive. A measurement is 121 mm. Is it acceptable? Explain using the boundary rule.

(Total for Question 6 is 2 marks)

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7 A turned brass bush has an outside diameter of 14.0 mm ± 0.2 mm and an inside diameter of 10.0 mm ± 0.1 mm. Both limits are included. Find the minimum and maximum wall thickness, assuming concentric diameters.

(Total for Question 7 is 3 marks)

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8 A 0.75 m steel rail is specified as 750 mm ± 2 mm, inclusive. Convert both acceptable limits into metres.

(Total for Question 8 is 2 marks)

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9 A plastic latch opening is specified as 32.0 mm ± 0.4 mm, inclusive. The table records four inspected openings. Calculate the proportion of these four that are defective, as a percentage.

Latch	Measured opening width (mm)
A	31.6
B	31.7
C	32.4
D	32.5

(Total for Question 9 is 3 marks)

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10 A batch of 40 recycled-plastic spacers is measured against a 5.0 mm ± 0.2 mm thickness specification, inclusive. The table summarises all measurements in this batch. Calculate the defective proportion as a fraction and percentage, and state one limitation when applying this result to future production.

Measured thickness (mm)	Number of spacers
4.7	2
4.8	7
5.0	20
5.2	8
5.3	3

(Total for Question 10 is 3 marks)

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11 A laser-cut bracket has a 24.0 mm ± 0.2 mm slot, with both limits included. A mating tab is 23.3 mm wide. Calculate the minimum and maximum clearance and decide whether the fit is guaranteed to have clearance throughout the allowed slot range. Treat the tab width as fixed and clearance as slot width minus tab width.

(Total for Question 11 is 3 marks)

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12 A dowel and hole have these specifications: hole diameter 10.0 mm ± 0.1 mm and dowel diameter 9.8 mm ± 0.1 mm, with all limits included. Calculate the smallest and largest possible diametral clearance (hole diameter minus dowel diameter). State whether a clearance fit is guaranteed for conforming parts and whether strictly positive clearance is guaranteed. A clearance fit permits zero clearance at a limiting size.

(Total for Question 12 is 4 marks)

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Mark scheme · 1.10 Tolerances and Quality Control

Question 1

lower limit = 20.0 - 0.3 = 19.7 mm **B1**

upper limit = 20.0 + 0.3 = 20.3 mm **B1**

Answer: 19.7 mm to 20.3 mm inclusive

Question 2

acceptable range is 2.32 mm to 2.48 mm **B1**

2.31 mm is below the lower limit but 2.34 mm is within tolerance; both round to 2.3 mm on this calliper, so its reading cannot distinguish their conformity (or another valid rounding example near a limit) **B1**

use a calibrated instrument with finer resolution and suitable accuracy for the limits, such as a micrometer reading to 0.01 mm; credit an equivalent suitable instrument **B1**

check zero/calibration against a known reference, or repeat measurements at consistent points with controlled measuring force; credit an equivalent valid check **B1**

Answer: 2.32 mm to 2.48 mm inclusive. The 2.31 mm clip fails and the 2.34 mm clip conforms, but both display 2.3 mm. Use a calibrated micrometer reading to 0.01 mm with suitable accuracy, and check its zero against a reference.

Question 3

acceptable interval is 299 mm to 301 mm inclusive **B1**

1 + 1 = 2 defective sampled panels; 2 / 20 x 100 = 10% defective in the sample **M1**

recommend inspecting more panels from across the batch, or every remaining panel, using a calibrated gauge; credit an equivalent suitable inspection step **B1**

justify further inspection because the sample contains defects and the uninspected panels may also contain defects; the sample does not establish the exact defective total among all 200 panels **B1**

Answer: 299 mm to 301 mm inclusive; 10% of the sample was defective. Inspect the remaining panels with a calibrated gauge because defects were found and the sample cannot establish how many of the uninspected panels conform.

Question 4

check and reset focus/alignment after lens changes, or verify and correct the cutting setup using a first-off piece, because errors cluster after that event; credit an equivalent improvement linked to the evidence **B1**

use a calibrated instrument to accept widths from 99.5 mm to 100.5 mm inclusive, including both boundary values **B1**

record measurements from repeated production runs or a suitable sample before and after the change **B1**

compare before/after defective proportions against the inclusive limits to assess improvement and investigate any out-of-range result; samples indicate performance but do not prove every unit conforms **B1**

Answer: Check and reset focus/alignment after lens changes because errors cluster then. Inspect first-off pieces and compare defective proportions from repeated runs before and after the change, accepting 99.5 mm to 100.5 mm inclusive. Investigate failures; samples do not prove every unit conforms.

Question 5

acceptable range is 7.95 mm to 8.05 mm inclusive **B1**

7.95 mm, 8.00 mm and 8.05 mm conform **B1**

7.94 mm and 8.06 mm fail: 2 pins **B1**

Answer: Conforming: 7.95, 8.00 and 8.05 mm; 2 fail

Question 6

upper limit is 120 + 1 = 121 mm **B1**

yes, it is acceptable because the stated boundary is included **B1**

Answer: Yes. 121 mm is the included upper limit.

Question 7

minimum wall = (minimum outside - maximum inside) / 2 **M1**

(13.8 - 10.1) / 2 = 1.85 mm **A1**

maximum wall = (14.2 - 9.9) / 2 = 2.15 mm **A1**

Answer: Minimum 1.85 mm; maximum 2.15 mm

Question 8

limits are 748 mm and 752 mm **M1**

divide by 1000: 0.748 m and 0.752 m **A1**

Answer: 0.748 m to 0.752 m inclusive

Question 9

acceptable interval is 31.6 mm to 32.4 mm inclusive **B1**

31.6, 31.7 and 32.4 mm conform; 32.5 mm fails, so 1 of 4 is defective **M1**

1 / 4 x 100 = 25% **A1**

Answer: 25% defective

Question 10

inclusive limits are 4.8 mm and 5.2 mm; 2 + 3 = 5 defective spacers, so defective fraction = 5 / 40 = 1 / 8 (or an equivalent fraction) **M1**

1 / 8 x 100 = 12.5% **A1**

the result describes this inspected batch only; it does not prove every uninspected spacer conforms **B1**

Answer: 1/8, or 12.5%; this batch result does not establish conformity of every unit

Question 11

slot limits are 23.8 mm and 24.2 mm **M1**

clearance = slot width - tab width: 23.8 - 23.3 = 0.5 mm; 24.2 - 23.3 = 0.9 mm **M1**

yes, clearance is guaranteed; the minimum is positive at 0.5 mm **A1**

Answer: Minimum clearance 0.5 mm, maximum 0.9 mm; clearance is guaranteed

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Question 12

minimum hole = 9.9 mm and maximum dowel = 9.9 mm **M1**

minimum clearance = 9.9 - 9.9 = 0.0 mm **M1**

maximum hole = 10.1 mm and minimum dowel = 9.7 mm; maximum clearance = 0.4 mm **M1**

yes, a clearance fit is guaranteed for conforming parts because clearance is never negative; strictly positive clearance is not guaranteed because the minimum is 0.0 mm **B1**

Answer: 0.0 mm to 0.4 mm inclusive. A clearance fit is guaranteed for conforming parts; strictly positive clearance is not guaranteed.

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