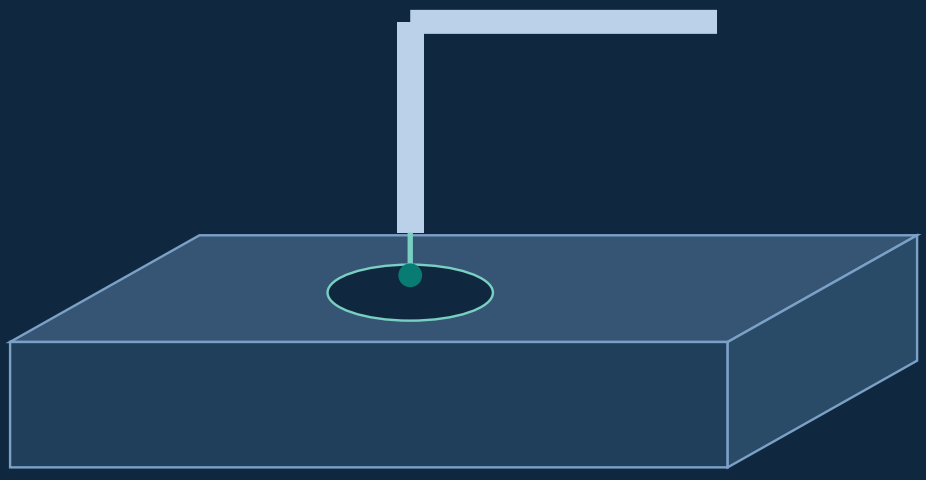
vetcnc
CNC MANUFACTURING

ENGINEERING RESOURCES / 04

CNC Part Inspection & Quality Acceptance

A Practical Guide

Read the result. Understand the uncertainty.
Release the right parts with the right evidence.



REQUIREMENT MEASUREMENT DISPOSITION

V1.0 / SEPTEMBER 2026

READER MAP

Use evidence to make the release decision

A practical guide for engineering buyers, inspectors and teams accepting custom CNC parts.

What you will be able to do

Turn a drawing into a characteristic register, ask whether the measurement method answers the drawing, interpret a result near a tolerance limit, and trace a released quantity back to the evidence. Worked examples connect these decisions to a small mounting block, a disputed bore and a contained production lot.

All part identities, inspection results, prices, lot records and program names in this guide are original teaching examples. They are not vetcnc customer projects, laboratory certificates or production capability claims. This guide complements the design, RFQ and materials resources; it does not authorize product release.

> **READ THIS CONVENTION FIRST**
>
> Unless stated otherwise, dimensions are mm; um means micrometre, or 0.001 mm. PASS, HOLD and FAIL describe only the stated check and decision rule. One passing feature is not a released part.

01 / WHAT INSPECTION ACTUALLY ESTABLISHES

Separate the three questions behind acceptance

Do not allow one green cell in a report to answer three different questions.

Each arrow needs an explicit, reviewable link.

Question	Evidence needed	What it does not replace
What was required?	Released drawing/model, revision, feature definition, final condition and acceptance rule.	A supplier's customary tolerance or a remembered email.
What was measured?	Part identity, method, setup, result, units and relevant uncertainty.	An instrument resolution or a machine sales specification.
What may be released?	Review of all required evidence, unresolved items, approved dispositions and exact quantity.	A first-article result used to approve every later lot.

A conformity statement concerns a specified characteristic under a stated rule. Release is a broader administrative and technical decision: the right material, surface condition, required records and delivery identity must also be resolved. Even a perfectly measured part can be the wrong revision.

Agree the decision rule before the first disputed measurement. A buyer and supplier can obtain similar readings yet disagree because one uses simple acceptance and the other applies a guard band. Changing the rule after seeing the result makes the commercial disagreement harder to resolve.

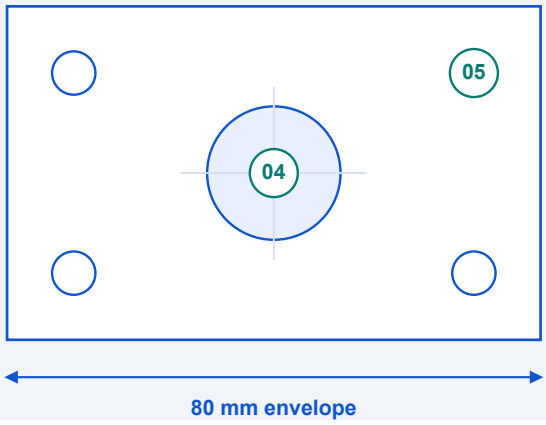
> **A STRONG OPENING QUESTION**
>
> Ask: "Which exact requirement, measured on which identified part in which final state, supports this acceptance decision?" If the answer cannot be reconstructed, request the missing evidence before release.

Sources: [10] BIPM / JCGM | [11] ISO | [20] ILAC

02 / ORIGINAL TEACHING CASE

Meet IB-80: a mounting block with real inspection questions

The part is deliberately simple enough to follow, while its interfaces demand more than a ruler and a photograph.



IB-80 / MOUNTING BLOCK

Central bore: size + coverage
Four holes: size + position
Mounting face: datum + flatness
Seat and threads: separate checks

CONCEPT MAP / NOT A PRODUCTION DRAWING

Feature group	Teaching design intent
Body / 80 x 50 x 15	Envelope controls mounting space; thickness controls the assembled stack.
Central 20 mm through bore	Final size is 20.000-20.020; diameter must be defined over the required feature, not only at its mouth.
Four 6.50 mm mounting holes	Size and position are separate characteristics. Their specified datum reference frame controls location.
Seat, blind threads and exterior	Seat texture, usable thread depth, masking, edge condition and finish each need their own evidence.

The fictional stock is 6061-T651 plate to a project-selected purchasing specification. Exterior treatment is defined in FIN-IB80 Rev A. Bore, mounting face, seat and threads have drawing-defined protection requirements. Every dimensional result in the example report is for the delivered state after all planned operations.

THIS IS A FEATURE MAP, NOT A RELEASED DRAWING

The sketch omits production-detail definitions. Its register and example report illustrate an inspection workflow. A real release must supply the complete drawing, process documents and acceptance plan.

03 / TWELVE REQUIREMENTS, NOT TWELVE ARBITRARY MEASUREMENTS

Build the characteristic register before the report

Assign stable identifiers to dimensions, notes, material and process requirements so nothing disappears between documents.

ID	IB-80 teaching requirement	Evidence route
01	Length 80.00 +/- 0.10	Final measured value
02	Width 50.00 +/- 0.10	Final measured value
03	Thickness 15.00 +/- 0.05	Defined locations / final value
04	Bore size 20.000-20.020	Defined size evaluation and coverage
05	4X hole size 6.50 +/- 0.10	Four individually identified results
06	4X position, diameter 0.20 to A | B | C	Drawing interpretation and evaluation
07	Mounting-face flatness 0.030 max	Surface sampling / evaluation
08	Seat texture Ra 1.6 um max	Controlled texture method SR-01
09	2X M6 x 1-6H; full thread 8.0 min	Size/function and usable-depth checks
10	Specified alloy, temper and product form	Material identity and lot records
11	Finish to FIN-IB80 Rev A and zone map	Process, masking and verification
12	Edges to ED-01 Rev A	Defined locations and defect criteria

Identifiers 05 and 06 each expand into four hole-specific records; 09 expands into two threads. A summary row must link those sub-results, not hide a failing hole behind an average. The same discipline applies to repeated dimensions and drawing notes.

> **KEEP INTERPRETATION UNDER CONTROL**
>
> For this example, position has no material-condition modifier. Do not add bonus tolerance or substitute XY coordinate tolerances. Apply the complete released definition and its agreed standard.

Sources: [01] ASME

04 / CONTROL THE POINT WHERE INFORMATION BECOMES USEFUL

Turn risk into an inspection plan

Inspection frequency, report scope and process checkpoints answer different questions.

IB-80 concern	Planned evidence	Reaction if unresolved
Wrong stock or revision	Identity review before irreversible machining; controlled file register.	Stop the affected route and reconcile documents.
Bore affected by later processing	Pre-process check where useful; final method after the complete surface route.	Hold affected pieces; investigate growth, masking and pre-size.
Mounting pattern cannot assemble	Datum-based position check using a validated program; preserve hole identities.	Review setup and definition before changing the part.
Threads obstructed or too shallow	Agreed functional and depth checks after cleaning and finish.	Segregate; do not force a gauge or improvise a repair.
Evidence missing at shipment	Release-package review matched to actual serials/lot and quantity.	Hold shipment authorization until disposition is recorded.

Specify which characteristics are checked on each part, which use an approved sampling plan and which are supported by process or material records. "Full inspection report" can mean all characteristics on one piece or selected characteristics on every piece; write the intended scope explicitly.

A practical plan names the characteristic, process stage, measurement instruction, equipment class, frequency, record, acceptance rule and reaction owner. A high-consequence failure can justify extra controls, but a blanket instruction to measure everything twice may add cost without addressing the actual escape mechanism.

> **USEFUL PROTOTYPE STARTING POINT**
>
> For the three-piece IB-80 teaching prototype, request individually identified results for all dimensional characteristics on all three pieces. This is a project choice, not a universal sampling requirement.

05 / MEASUREMENT-METHOD SELECTION

Choose a method that can answer the requirement

Instrument names are not capability statements. Access, form, force, setup and uncertainty determine usefulness.

Requirement	Potential method	Question before approving it
Accessible external size	Micrometer, comparator or suitable coordinate measurement	Are contact geometry, force, range and uncertainty appropriate?
Internal bore size	Bore comparator, internal micrometer, air gauge or CMM strategy	Which depths/directions and size definition are covered?
Hole position	CMM or another validated coordinate/functional method	Does setup reproduce the required datum system and evaluation?
Flatness / profile	Adequate surface sampling and correct evaluation	Can the strategy detect the relevant form departures?
Thread acceptance	Correct thread gauges plus separate specified depth/geometry checks	Are designation, gauge limits, condition and use procedure controlled?
Surface texture	Appropriate profilometer and specified evaluation method	Are parameter, filtering, direction and sampling settings agreed?

A 0.001 mm display increment means the display changes in 0.001 mm steps; it does not establish 0.001 mm measurement uncertainty. Likewise, a CMM length-error specification cannot simply be copied into every feature row as that feature's uncertainty.

For a tight feature, ask for evidence from a similar task or a justified task-specific evaluation. A fast production comparator may be excellent for one bore family while a more versatile machine may require a carefully designed strategy. Choose by demonstrated fitness for the actual decision.

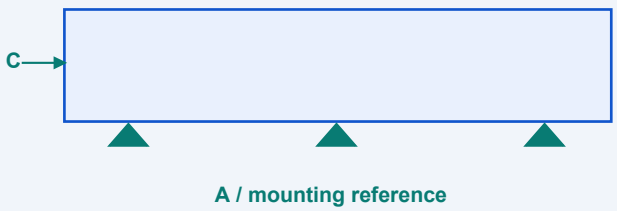
> **COST-EFFECTIVE DOES NOT MEAN UNDERSPECIFIED**
>
> Allow the supplier to propose an efficient method, provided it measures the ordered characteristic with the agreed uncertainty and decision rule. Do not prescribe equipment merely for its appearance.

Sources: [03] NPL | [05] NPL

06 / DATUMS, ALIGNMENT AND FEATURE MEANING

The coordinate system is part of the measurement

A different alignment can produce a different result without any change to the part.



Follow the released datum order.
Do not substitute a convenient best fit for the specified frame.

Conceptual support view only.

In the IB-80 concept, A is the mounting face, B a specified long side and C an adjacent end. The released drawing controls datum precedence and the features used to establish the reference frame. The inspector must not replace that frame with a convenient best fit that hides a positional error.

Review item	What the inspection record should clarify
Datum realization	Which surfaces/features are used, in which order, with what constraints and evaluation.
Part restraint	Contact locations, clamping and any permitted constrained condition.
Feature extraction	What points or scan paths represent the bore, hole axis or surface.
Evaluation settings	Applicable size/form/position definition, fitting criteria and software/program revision.

Three points mathematically define a plane, but they do not demonstrate that a manufactured surface is flat. Similarly, a circle constructed through three points may completely miss a form error between those points. The minimum data needed to compute a feature are not automatically enough to inspect it.

DO NOT MIX SPECIFICATION SYSTEMS BY HABIT

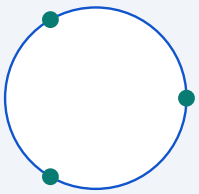
Use the drawing's agreed interpretation, including applicable defaults and modifiers. This conceptual datum sketch is not a full GD&T; instruction or a substitute for the selected standard.

Sources: [01] ASME | [04] NPL

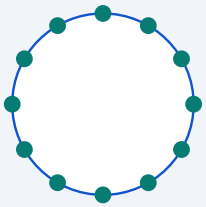
07 / PROBE COVERAGE, FITTING AND PROGRAM CONTROL

A CMM report is only as good as its strategy

More decimal places do not repair missing surface information.



Sparse section



Broader section sampling

Point count and placement must suit the actual feature.

Both sketches omit depth. Neither is a universal rule.

Program choice	Consequence to review
Point distribution and depth levels	A single circular section may miss taper, bellmouth or local damage elsewhere in a bore.
Probe and approach	Stylus access, contact direction, qualification and surface interaction affect results.
Fitting and filtering	A least-squares result, a boundary-based result and an unfiltered extreme may answer different questions.
CAD and program revision	An old nominal model or a changed alignment can invalidate otherwise plausible numbers.

For IB-80, request a documented strategy that covers the specified bore and mounting features. Validate it with representative parts or reference evidence, including challenging geometry. Do not turn the illustrative point patterns into a universal minimum or a guarantee that lobing will be detected.

Retain program identity, operator/setup, stylus configuration, relevant environmental record and raw feature evidence where needed for a dispute. A colour map is useful for locating deviation, but the legend, datum alignment, filters and evaluation scope still determine what it means.

SEPARATE MACHINE VERIFICATION FROM PART-TASK CAPABILITY

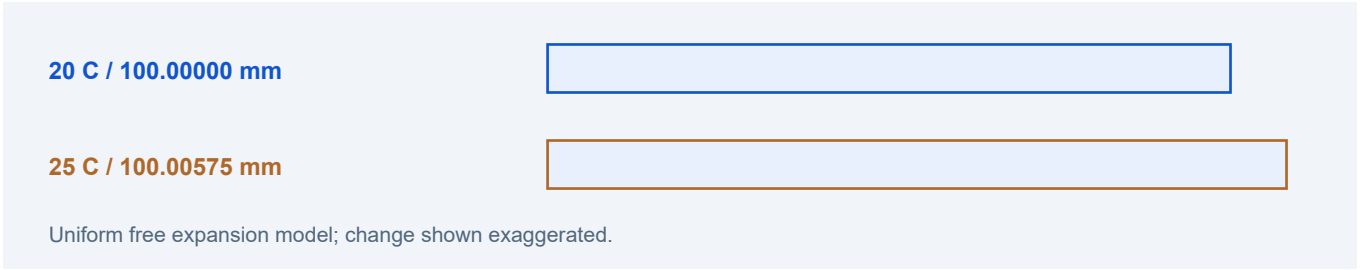
Periodic verification supports confidence in the machine. Task-specific uncertainty also depends on the part, probing, setup, software and conditions. A calibration sticker cannot resolve those choices.

Sources: [04] NPL | [05] NPL

08 / MEASUREMENT STATE AND A WORKED CORRECTION

Temperature can consume the tolerance you are debating

Agree the reference condition before comparing values from two rooms.



Uniform free expansion model; change shown exaggerated.

For an original thermal example, assume a freely expanding steel length with L20 = 100.000 mm, uniform part temperature 25 C, and a known constant expansion coefficient of 11.5 x 10^-6 /K. The coefficient is an assumed teaching input, not a value guaranteed for every steel.

Calculation	Result
Temperature difference: 25 - 20	5 K
Expansion: 100.000 x 11.5 x 10^-6 x 5	0.00575 mm
True length at 25 C in this model	100.00575 mm
Recover reference length: L25 / (1 + alpha x delta T)	100.00000 mm

If a measurement system already compensates to 20 C, subtracting this expansion again is wrong. A real instrument and workpiece may both expand, and their temperatures may differ. Identify what the reported value represents, how compensation was applied and which residual temperature/coefficient uncertainties remain.

Clean and stabilize the part using a justified procedure. Air temperature alone does not prove that a thick component has equilibrated. Handling, a warm spindle-side part and a local gradient can matter. There is no universal "wait 15 minutes" rule that establishes the correct measurement state for every geometry.

> **INSPECTION CONDITION IS NOT SERVICE APPROVAL**
>
> An accepted dimension at the agreed reference condition does not prove that the assembly will fit at its operating temperature. Treat service expansion as a separate design check.

Sources: [03] NPL | [06] NIST

09 / TRACEABILITY AND FITNESS FOR USE

Read the calibration evidence, not just the sticker

A current date is helpful, but it does not tell you what was calibrated or how well.

Certificate item	Buyer/inspector review
Equipment identity and range	Does the serial number match the instrument, and do relevant points/functions cover the intended use?
Reported indication error / correction	Was a known correction applied where needed? Is the sign understood?
Uncertainty and coverage statement	Is the uncertainty suitable for the task, and is k or another coverage basis stated?
As-found / as-left state	Could adjustment or an out-of-tolerance finding affect earlier product measurements?
Traceability and service scope	Does the documented chain and, where required, accredited scope cover the service?
Use between calibrations	What checks detect damage, drift, contamination or an invalid setup before the next due date?

A correction-sign example

Assume a calibration result states indication error = indicated value minus reference value = +0.003 mm at the relevant point. The corresponding correction is -0.003 mm. An indicated 20.014 mm would become 20.011 mm before other corrections. Uncertainty remains; correcting a known error does not remove every source of doubt.

NIST describes traceability in terms of a measurement result and a documented chain of calibrations with uncertainty [02]. "NIST traceable" is not a NIST product approval, and traceability alone does not ensure that a result is accurate enough for the intended acceptance decision.

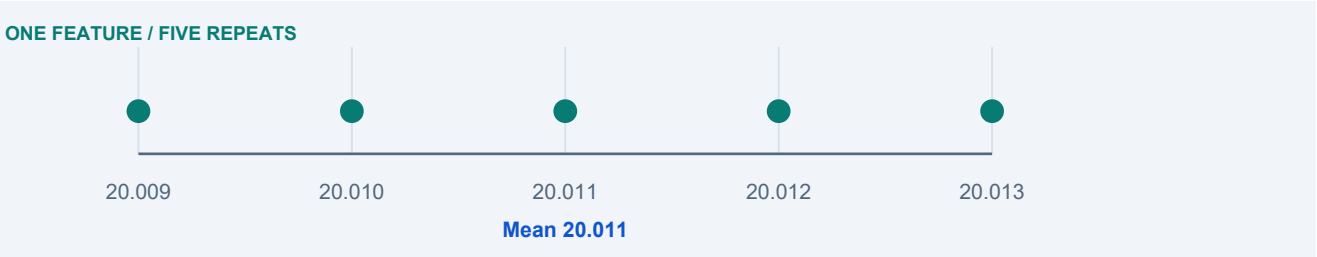
> **WHEN A GAUGE IS FOUND UNSUITABLE**
>
> Identify the potentially affected work, time interval and characteristics, then assess impact using evidence. Do not automatically condemn every part or silently ignore the earlier measurements.

Sources: [02] NIST | [06] NIST

10 / REPEATABILITY, SPREAD AND THE MEAN

Five repeated readings answer a limited question

These are repeated observations of one unchanged teaching measurand, not five different parts.



Quantity	Calculation / interpretation
Readings / mm	20.010, 20.012, 20.011, 20.013, 20.009
Mean	Sum / 5 = 20.011 mm
Observed range	20.013 - 20.009 = 0.004 mm
Sample standard deviation s	sqrt[sum((xi - mean)^2) / (n - 1)] = 0.001581 mm
Standard uncertainty of the mean	s / sqrt(5) = 0.000707 mm, under the assumptions below

The s / sqrt(n) reduction applies when the reported result is the mean of independent repeat observations of the same stable quantity under the model. It does not justify using 0.000707 mm for a single reading, for changing temperatures, or for different bore sections that represent real shape variation.

A small repeatability spread does not prove negligible bias. An instrument with a persistent offset can repeat very well. These five values also say little about another operator, another fixture, another day or a changed probe. A measurement-system study must address the intended sources of variation.

> **DO NOT AVERAGE AWAY THE WRONG THING**
>
> If three diameters at different depths are 20.006, 20.012 and 20.022, their mean is not a substitute for checking the specified bore characteristic. Preserve the location-specific data and evaluate the actual size/form requirement.

Sources: [07] NIST | [17] NIST / SEMATECH

11 / WORKED TEACHING BUDGET

Build a small uncertainty budget you can audit

Define the measurand and model before adding numbers. All inputs below are assumed for instruction.

Model a corrected, 20 C-referenced local bore-size result reported as the mean of five repeats. Use the repeatability from page 12. Assume the remaining calibration, temperature and alignment residuals below are independent, expressed as equivalent length contributions, and not already counted in the repeatability term.

Component / assumed evidence	Conversion to standard u	u / um
Mean repeatability: s = 1.581 um, n = 5	s / sqrt(5)	0.707
Calibration: U = 2.0 um, k = 2	U / k	1.000
Residual temperature +/- 2 K, rectangular; L = 20 mm, alpha = 11.5 x 10^-6 /K	L x alpha x 2 / sqrt(3)	0.266
Residual alignment +/- 1.0 um, rectangular	1.0 / sqrt(3)	0.577

With sensitivity factors already included and covariance assumed zero: uc = sqrt(0.707^2 + 1.000^2 + 0.266^2 + 0.577^2) = about 1.380 um. Using unrounded inputs gives U = 2uc = 2.760 um = 0.002760 mm for the assumed k = 2. This is a worked budget, not a validated laboratory uncertainty.

Resolution is not a free extra accuracy claim

For a separately justified rounding model with increment q = 1 um, uniform error over +/- q/2 gives q / sqrt(12) = 0.289 um. Do not automatically add it again if its effect is already represented in observed repeatability. Review overlap, correlations, missed thermal gradients, master-gauge behavior and geometric coverage.

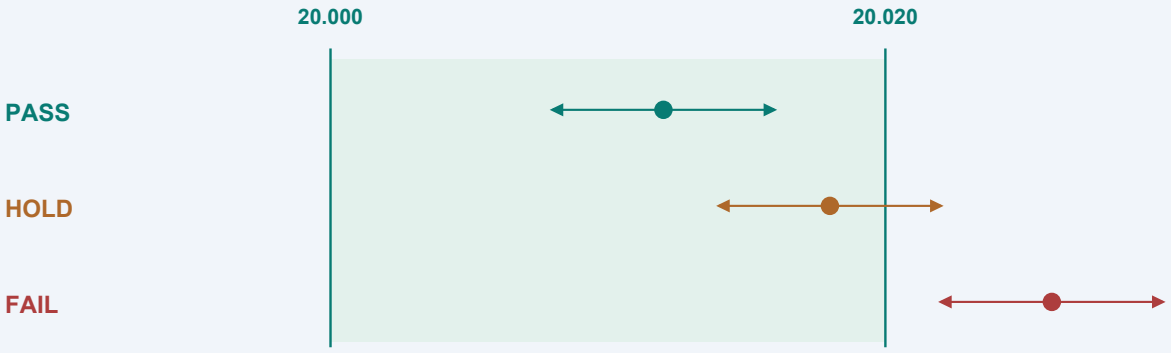
> **COVERAGE NEEDS JUSTIFICATION**
>
> k = 2 is not automatically an exact 95% interval, particularly with limited data or non-normal components. Establish the appropriate coverage treatment and report its basis. Page 14 uses a different, explicitly stipulated U for its decision example.

Sources: [07] NIST | [08] NIST | [09] NIST

12 / A TRANSPARENT THREE-WAY TEACHING AGREEMENT

State the decision rule before you see the result

This example is an agreed interval rule, not a claim to reproduce every ISO 14253-1 default.



Each bar: y +/- 0.004 mm

For a two-sided requirement LSL <= size <= USL, let y be the corrected result and U the applicable expanded uncertainty. The teaching agreement below uses the interval [y - U, y + U]. Equality at a specification boundary is included for PASS; the rule and treatment of equality must be agreed in a real job.

Status	Rule used in this guide
PASS	The complete interval is inside the specified limits: y - U >= LSL and y + U <= USL.
FAIL	The complete interval is outside one limit: y + U < LSL or y - U > USL.
HOLD	All remaining cases. The result does not meet either of the above demonstration rules. Resolve by an approved route.

For the 20.000-20.020 bore and U = 0.004, the PASS range for y is 20.004-20.016. This guard band narrows the acceptance region; it does not change the drawing tolerance. A value outside this acceptance region is not automatically a demonstrated nonconformance under the three-way rule.

> **USE THE ACTUAL CONTRACTUAL RULE**
>
> Simple acceptance, probability-based rules and other guard bands allocate risk differently. ISO 14253-1:2017 addresses GPS decision rules [11]; do not label this symmetric interval example its universal default.

Sources: [10] BIPM / JCGM | [11] ISO | [20] ILAC

13 / THREE READINGS AND ONE DOCUMENTED FOLLOW-UP

Resolve a borderline bore without moving the goalposts

Use the same requirement and a justified measurement route, not whichever result happens to pass.

Result y / U, mm	Interval / mm	Teaching decision
20.012 / 0.004	20.008-20.016	PASS
20.018 / 0.004	20.014-20.022	HOLD: overlaps upper limit
20.026 / 0.004	20.022-20.030	FAIL: wholly above upper limit

The second result is nominally below 20.020, yet it is not a PASS under the agreed rule. The third result is a demonstrated FAIL within the stated rule. Neither statement changes the true part; each describes what the measurement supports with the selected uncertainty treatment.

Follow-up for IB-80 serial 001

First confirm identity, cleanliness, reference condition and the same bore-size definition. Then use an independently justified improved method or setup. Suppose the approved follow-up reports y = 20.0170 and U = 0.0015. Its interval is 20.0155-20.0185, wholly inside the limits, so this feature now passes the same rule.

Retain both records, explain why the new method is more suitable, and investigate any meaningful difference between results. Do not delete the original HOLD, average unlike methods, select the lowest of repeated results, or retroactively enlarge the tolerance. The unresolved surface or material records still need separate closure.

> **A SMALLER U MUST BE EARNED**
>
> Changing a report cell from 0.004 to 0.0015 without supporting method evidence is not a remeasurement. If the feature remains unresolved, maintain HOLD or seek an authorized disposition; do not relabel uncertainty as conformity.

Sources: [10] BIPM / JCGM | [11] ISO

14 / IB-80 SERIAL 001, ORIGINAL EXAMPLE

Read a completed dimensional report row by row

All limits and results below are mm. U is expanded uncertainty, with k = 2 assumed for this teaching report.

ID / feature	Limits	Result y / U	Status
01 / length	79.90-80.10	80.034 / 0.010	PASS
02 / width	49.90-50.10	49.982 / 0.010	PASS
03 / thickness	14.95-15.05	15.009 / 0.006	PASS
04 / bore	20.000-20.020	20.018 / 0.004	HOLD
05 / four holes	6.40-6.60 each	6.512, 6.508, 6.495, 6.506; U 0.010 each	PASS
06 / four positions	0.200 max each	Max 0.166 / 0.018; see sub-results	PASS
07 / flatness	0.030 max	0.034 / 0.003	FAIL

For one-sided nonnegative form/position characteristics in this teaching report, PASS requires y + U <= upper limit; FAIL requires y - U > upper limit; otherwise HOLD. Thus position gives 0.166 + 0.018 = 0.184 <= 0.200. Flatness gives 0.034 - 0.003 = 0.031 > 0.030 and fails.

Read the linked records, not just this summary

Hole IDs H1-H4 map to the drawing and raw file IB80-001-DIM-A. Position results are 0.142, 0.166, 0.121 and 0.151, each with stipulated U = 0.018. The bore and flatness evaluations have separate strategy records. Equipment, setup, method issue and measurement state are retained in the report header and attachments.

The example release status is HOLD because a confirmed failed characteristic and a borderline characteristic remain unresolved. The bore follow-up on page 15 may close ID 04, but it cannot close the flatness failure. A report with many green rows can still describe a non-releasable part.

> **NO CAPABILITY CLAIM IS MADE**
>
> These invented readings demonstrate arithmetic and review logic. They do not establish that any named machine, supplier or process achieves the listed uncertainties.

15 / SURFACE, THREAD AND DOCUMENTARY EVIDENCE

Finish the report beyond the dimensions

Material and process notes are requirements too. A dimension-only report leaves an incomplete release decision.

ID / requirement	Teaching evidence for serial 001	Disposition
08 / seat Ra <= 1.6 um	SR-01 gives 1.1, 1.3 and 1.2 um at defined paths; U = 0.2 um each. Each trace must pass.	PASS: max + U = 1.5 um
09 / two M6 threads	Both meet the approved thread-gauging procedure; usable depths 8.3 and 8.4 mm, U = 0.1 mm each.	PASS: min - U = 8.2 >= 8.0
10 / material identity	Lot label matches the stock record, but the requested temper evidence is absent.	HOLD: evidence gap
11 / finish and masks	Treatment record references FIN-IB80 Rev A; zone checks and approved appearance comparison are linked.	PASS for defined checks
12 / edges to ED-01	Location E2 has a visible remaining burr meeting the agreed reject criterion; image E2-001 retained.	FAIL: local condition

The texture and thread-depth uncertainty values are stipulated examples, not recommended instrument specifications. The functional thread gauge result is an attribute decision under its controlled procedure; it is not converted into a fabricated numerical uncertainty interval. The 8.2 mm calculation concerns the separate depth check only.

A missing material record is an evidence gap, not proof of wrong alloy. Preserve that distinction in the nonconformance report. Ask for the required traceable record or an approved verification route; do not fill the cell with an unsupported "material OK."

CURRENT STATUS OF SERIAL 001

HOLD. ID 04 needs closure, ID 07 and ID 12 need disposition, and ID 10 needs evidence. Even after the bore passes its follow-up, the part is not ready for release.

16 / TRACEABILITY FROM STOCK TO THE DELIVERED PART

Make the evidence chain survive shipment

A document is useful only when you can show which supplied parts it supports.

Preserve identity through splitting, batching, inspection and packing.

Link	Practical record
Purchase order to engineering release	PO line, part number, revision and controlled attachments.
Stock to machining lot	Stock identity, material/heat/lot reference and the required material evidence.
Machining lot to special process	Part identities, quantity, treatment issue and the process batch or job record.
Part to inspection	Serial or agreed traceable grouping, method/program issue, results and disposition.
Released quantity to packing	Packing list, label identities, release record and any approved exception.

If a bar is split into several jobs, preserve the link through the cut pieces using a suitable controlled identification method. If treatment combines multiple machining lots, record the relationship rather than replacing every original identity with one new batch label. The required traceability depth depends on the contract and risk.

Distinguish a declaration of conformity, a material test record, a process certificate and an actual dimensional report. Their purposes overlap only where expressly defined. None should be represented as automatically proving every other requirement.

> **A SIMPLE RECONCILIATION TEST**
>
> Select one packed piece. Can the reviewer reconstruct its part revision, relevant material/process identity, inspection status and release authority without guessing? Investigate broken links before dispatch.

17 / DEFINE WHAT THE INITIAL EVIDENCE PACKAGE MUST COVER

First article inspection is a baseline, not a lifetime pass

A first article helps evaluate the production definition and realization route; later control is still needed.

Package element	What the reviewer should be able to establish
Part and configuration	Which released part, model, drawing and process configuration was inspected.
Characteristic accountability	Every applicable requirement is identified; repeated features, notes and process requirements are included.
Actual results and evidence	Measured values, relevant attributes and supporting records map to the characteristics and part identities.
Exceptions and closure	Each discrepancy has a controlled disposition and any required re-verification.
Change/review trigger	The agreement identifies changes that require renewed evaluation of affected characteristics.

For the three-piece IB-80 prototype, a useful package includes the register, individual dimensional results, thread/texture checks, material and finish records, and closure of the known exceptions. Do not submit a report for serial 001 as though it measured serials 002 and 003.

A change in manufacturing site, fixture, stock condition, finish route or measurement program can affect what the original evidence demonstrated. Assess the changed scope and determine the required renewed review. Do not invent a universal requalification interval when the applicable customer or industry system already defines one.

If the customer invokes AS9102

SAE AS9102C establishes aerospace FAI requirements complementary to customer and applicable regulatory requirements [13]. Obtain and apply the full invoked issue. This guide's register and blank forms are original general-purpose aids, not official AS9102 forms or evidence that vetcnc holds an aerospace certification.

Sources: [13] SAE International

18 / A SHINY SURFACE CAN STILL BE THE WRONG SURFACE

Surface texture needs a measurement recipe

Specify the characteristic and evaluation settings before comparing roughness numbers.

SCHEMATIC PROFILE / NO NUMERIC SCALE

Same surface, different settings?
The number may change.

Retain the evaluation recipe.

Define in SR-01 or equivalent	Reason
Parameter, limit and units	Ra, Rz and other parameters are not interchangeable labels; um and microinch are different units.
Controlled standard and evaluation settings	Filtering, evaluation length and applicable operators influence the result.
Location and direction	A trace across the machining lay can differ from one along it; define representative and functional paths.
Instrument/probe and access	Tip geometry, force, range and inaccessible areas can affect the task.
Decision and reporting	Retain individual required traces, settings and applicable uncertainty; do not replace a maximum criterion with an average.

For the teaching seat, the procedure requires each defined trace to meet Ra <= 1.6 um using the agreed rule. Results 1.1, 1.3 and 1.2 with U = 0.2 each pass because the largest upper bound is 1.5 um. The rule would need review if the drawing specified a different statistical operator or acceptance convention.

KEEP VISUAL AND MEASURED ACCEPTANCE SEPARATE

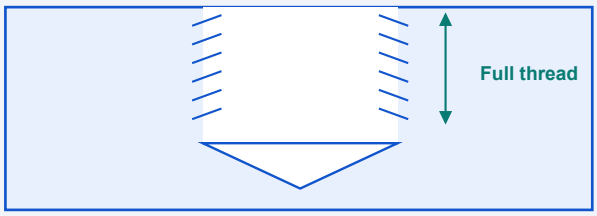
A roughness result does not establish freedom from a burr, scratch or isolated sealing defect. Conversely, a pleasing photograph does not measure Ra. Link visual defect criteria to the intended functional zones.

Sources: [03] NPL | [12] ISO

19 / FUNCTIONAL GAUGING AND USABLE DEPTH

Threads need more than a successful screw trial

A customer screw is not automatically a calibrated acceptance gauge.



Usable thread depth is not drill depth or tap travel.

Section concept only: lead/runout simplified.

Check	Record / interpretation
Thread identity	System, nominal size, pitch, class, handedness and required extent.
Gauge identity and condition	Correct gauge designation, status, cleanliness, wear checks and approved use procedure.
GO / NOT GO evaluation	Apply the specified procedure and limits; do not invent a universal allowed turn count.
Usable full-thread depth	Verify the specified depth separately; tap lead, runout and drill point are not usable full thread.
Final state	Check after operations that can alter the thread, including coating and final cleaning.

For the two IB-80 blind threads, the teaching requirement is at least 8.0 mm of usable full thread. Depth results 8.3 and 8.4 with U = 0.1 give lower bounds of 8.2 and 8.3 mm. This supports the depth check only; thread size/function must also meet the approved gauging procedure.

DO NOT FORCE THE RESULT

If a gauge binds, preserve the condition and investigate contamination, burrs, coating, geometry or an incorrect gauge. Forcing, chasing or retapping is a process change or rework action that needs appropriate approval and re-verification.

Sources: [03] NPL

20 / RESTRAINT, FORCE AND CONDITIONING

Clamping can hide a flexible part's shape error

Thin walls and polymers make the measurement state visible in the result.

Risk	Define the comparison
Clamping changes shape	Free-state or specified restrained condition; support, clamp locations and loading.
Contact force distorts a feature	Suitable force/contact geometry and a validated method for the material and wall thickness.
Temperature or moisture changes size	Inspection state, conditioning history and relevant stabilization evidence.
Machining stress relaxes	Time and process stage at measurement; free-state checks where required.

Consider a teaching plate with a free-state flatness limit of 0.050. A clamped measurement reports 0.028, while the defined free-state method reports 0.074 with U = 0.008. The latter lower bound is 0.066 > 0.050, so it fails the stated rule. The clamped value does not demonstrate compliance with a free-state requirement.

If the design actually requires verification in a restrained assembly condition, that condition must be specified and reproduced. Do not assume the free-state result always controls, or that any convenient fixture is representative. Changing the measurement state after a failure changes the question being answered.

> **DO NOT CONFUSE CONDITIONING WITH PERMISSION TO CHANGE THE PART**
>
> A defined stabilization procedure supports comparable measurement. An unapproved heating, drying or mechanical straightening operation may change the product and requires separate review.

Sources: [03] NPL | [04] NPL

21 / DEFINE THE LOT AND THE ACCEPTANCE SCHEME

Sampling is a risk decision, not a shortcut phrase

"Check a few pieces" is not enough to establish a reproducible lot decision.

Specify	Why it matters
Lot definition and boundaries	Which pieces share the relevant process, revision and condition; avoid convenient mixing after a failure.
Unit and defect classification	What counts as one inspected unit and one nonconforming unit; one part may have several defects.
Selection method	A random or otherwise justified representative selection, not only the easiest pieces to reach.
Plan, sample size and acceptance criterion	The actual scheme, severity, AQL or risk basis, and applicable switching/disposition rules.
Characteristic coverage	Which checks apply to each selected unit, and which need different controls.
Reaction to a failed sample	Hold, investigation, authorized sorting or other defined disposition; no informal resampling until a pass.

ISO 2859-1:2026 is the current public edition record for AQL-indexed attribute sampling schemes [16]. A real plan needs the agreed complete scheme and its conditions. This guide does not reproduce tables, choose an AQL for your application or equate an AQL with a guaranteed defect percentage in a delivered lot.

A first article addresses defined initial evidence; acceptance sampling addresses a lot decision; process control monitors change over production. They complement one another but are not interchangeable. Critical or high-consequence characteristics may require a different strategy determined by the responsible engineering and quality team.

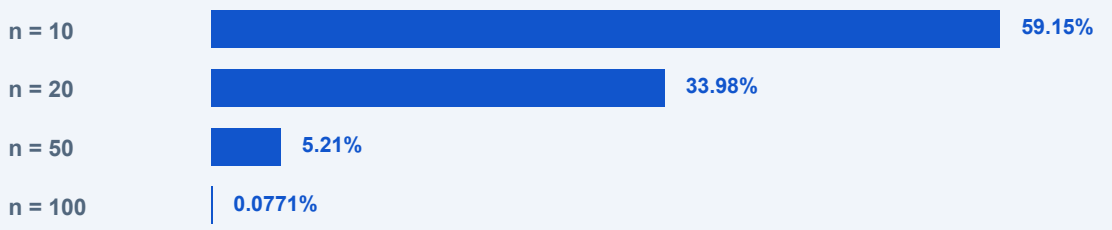
> **KEEP UNCERTAINTY IN THE CLASSIFICATION STEP**
>
> A sampling calculation commonly assumes every sampled unit is classified correctly. A poor measurement method can violate that assumption before the statistical acceptance rule is even applied.

Sources: [14] NIST / SEMATECH | [16] ISO

22 / EXACT FINITE-LOT ARITHMETIC

Zero defects in the sample does not mean zero in the lot

This original example assumes perfect detection and a genuinely random sample without replacement.



Chance of finding none of the 10 bad pieces in a 200-piece lot.

Imagine a lot of N = 200 pieces that actually contains D = 10 nonconforming pieces. The inspector does not know which ten. A teaching c = 0 rule accepts only when the sample contains zero nonconforming pieces. It is not presented as an ISO 2859 plan or a recommendation.

Random sample n	P(no nonconforming piece found)	P(at least one found)
10	59.15%	40.85%
20	33.98%	66.02%
50	5.21%	94.79%
100	0.0771%	99.9229%

For n = 20, P(no detection) = C(190,20) / C(200,20) = 0.339774. C(a,b) is the number of ways to choose b items from a. The hypergeometric model [15] accounts for selection without replacement. This probability is conditional on the stipulated ten bad pieces; it is not the probability that an observed lot is good.

A larger random sample reduces the chance of missing these defects, but cost, destructive testing and classification errors still matter. Sampling the first twenty pieces after a tool change is not equivalent to random selection across the whole lot. Use the model to discuss risk, not to invent assurance.

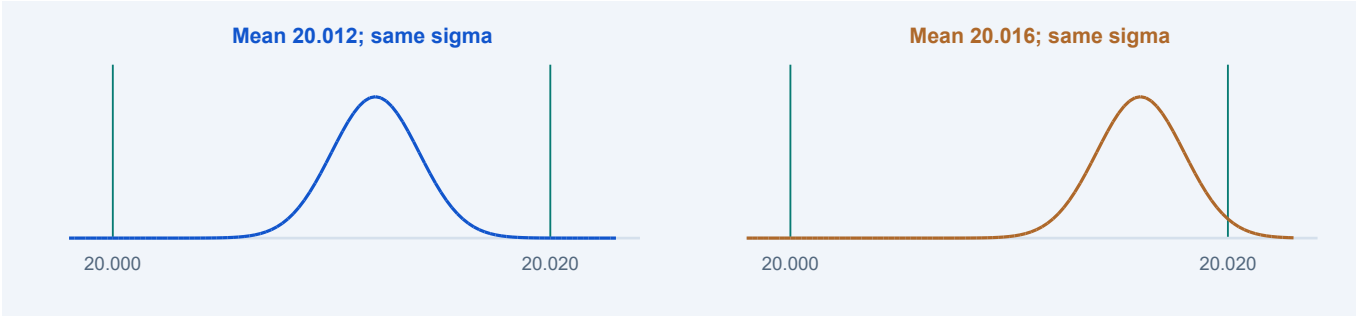
> **100% INSPECTION ALSO NEEDS A CAPABLE METHOD**
>
> Checking every piece eliminates unsampled pieces for that check, but it does not eliminate missed characteristics, wrong limits, misidentification or measurement error.

Sources: [14] NIST / SEMATECH | [15] R Core / stats

23 / CP AND CPK WITH EXPLICIT ASSUMPTIONS

Capability describes a process, not one report

Use a stable, appropriately modelled process and a credible measurement system before interpreting an index.



Assume a stable normal process with true mean 20.012 mm and standard deviation sigma = 0.002 mm, against LSL = 20.000 and USL = 20.020. These are stipulated population values for teaching, not estimates from the three IB-80 prototype parts.

Index	Calculation	Result
Cp	(20.020 - 20.000) / (6 x 0.002)	1.667
Upper capability	(20.020 - 20.012) / (3 x 0.002)	1.333
Lower capability	(20.012 - 20.000) / (3 x 0.002)	2.000
Cpk	Minimum of upper and lower values	1.333

If the mean shifts to 20.016 with the same sigma, Cp remains 1.667 but Cpk falls to (20.020 - 20.016) / 0.006 = 0.667. Spread and centering are different issues. If the process is drifting, a single pooled index can hide the change rather than describe a stable population.

> **DO NOT TURN AN INDEX INTO A RELEASE GUARANTEE**
>
> Estimation uncertainty, time coverage, distribution shape, subgroup strategy and measurement effects matter. Agree thresholds and methodology for the application. Three passing first-article pieces do not establish long-term capability.

Sources: [18] NIST / SEMATECH | [19] NIST / SEMATECH

24 / REPEATABILITY, REPRODUCIBILITY AND BIAS

Check the measurement system before blaming the process

Repeated readings by one person do not establish performance across operators, days and setups.

Source of variation	Study question
Within one setup	Does the same operator/method repeat on a stable part?
Between operators or reloads	Do technique, contact force or fixturing change the result?
Across time	Does the reference check drift between calibrations or shifts?
Across feature size or geometry	Does performance change over the range or on difficult features?
Persistent offset	Is there a bias relative to a suitable reference, and is it corrected?

A variance example with a narrow meaning

Assume independent additive, zero-mean measurement error. If observed standard deviation is 0.004 mm and a justified measurement study gives sigma measurement = 0.003 mm, then sigma process = sqrt(0.004^2 - 0.003^2) = 0.002646 mm. These assumed values explain variance addition; they do not authorize subtracting uncertainty from individual product results.

In this scenario the six-sigma measurement spread is 6 x 0.003 = 0.018 mm, or 90% of a 0.020 mm tolerance width. That is a serious signal to review the decision method, not a universal pass/fail threshold copied from a handbook. Standard deviation, expanded uncertainty and instrument error limits are different quantities.

Use representative parts spanning relevant variation; preserve blind/randomized measurement order where appropriate; include the operators and reloading conditions that actually occur. A crossed study may not suit destructive tests or unstable parts. Have the analysis match the design rather than forcing every study into one spreadsheet template.

> **WHAT PAGE 12 DOES NOT ESTABLISH**
>
> Five repeats on one feature are useful for one component of a budget. They are not a full gauge R&R; study, proof of no bias, or evidence that the system can classify every production geometry.

Sources: [07] NIST | [17] NIST / SEMATECH

25 / A STRUCTURED MEASUREMENT DISPUTE

When two reports disagree, compare the same measurand

Do not start by averaging the two numbers or choosing the more expensive instrument.

Reconcile first	Concrete question
Identity and condition	Same serial, revision, finish state, cleanliness, temperature and restraint?
Characteristic definition	Same bore section, local size or fitted feature; same datum and evaluation?
Method and corrections	Same correction convention, compensation, force and relevant coverage?
Uncertainty and rule	Comparable coverage basis; which rule produced each status?
Follow-up authority	Who approves the referee method and how are all records retained?

Suppose laboratory A reports 20.014 +/- 0.004 mm and B reports 20.019 +/- 0.003 mm, both with stipulated k = 2. A passes the page 14 rule for the 20.000-20.020 bore; B is HOLD. Overlapping intervals do not make their conformity statements identical.

An arithmetic check on the difference

The difference is 0.005 mm. If the two standard uncertainties are independent and comparable, u difference = sqrt((0.004/2)^2 + (0.003/2)^2) = 0.0025 mm. The corresponding k = 2 interval half-width is 0.005 mm. This comparison is consistent with a borderline difference under the model; it does not prove either method is unbiased or that the part passes.

Shared calibration references, correlated corrections or different measurands invalidate that simple independence model. Reconcile the definitions and investigate the method before applying statistics. Preserve the original records and obtain an agreed, technically justified referee measurement if needed.

> **A COMMERCIAL RESOLUTION IS NOT A DATA CORRECTION**
>
> A customer may authorize a limited concession through its controlled process. Record that as a concession, not as a rewritten measurement or a normal conformity statement.

Sources: [07] NIST | [10] BIPM / JCGM

26 / OBSERVATION, CONTAINMENT AND DISPOSITION

Write a nonconformance that someone can act on

A useful record separates what was observed from why it happened and who may approve the response.

Record field	Completed IB-80 teaching entry
Identity / requirement	NCR-IB80-001; serial 001; drawing Rev A, ID 07; mounting-face flatness <= 0.030 mm.
Objective evidence	Final-state result 0.034 mm; U = 0.003, k = 2 stipulated; lower bound 0.031 > 0.030 under rule DR-01.
Immediate control	Serial 001 held; related pieces reviewed for common fixture/process exposure. No shipment authorization.
Evidence retained	Program/setup issue, measured point file, surface identity, environment record and original report.
Cause status	Not yet established. Candidate mechanisms include restraint effects and machining sequence; investigate before asserting a cause.
Proposed action / authority	Engineering review of a possible face-finishing route; no machining until scope and affected-feature checks are approved.

The material-record gap at ID 10 and burr at ID 12 are separate findings or explicitly linked line items. A material evidence request is not the same as a dimensional repair. Combining unrelated issues into "part bad" makes closure ambiguous.

Rework, repair, use-as-is concession and scrap have different implications. Use the definitions and authority in the applicable quality system. A supplier should not decide that a failed interface is acceptable merely because it still assembles in one trial.

> **DO NOT JUMP TO A CONVENIENT ROOT CAUSE**
>
> "Operator error" without evidence does not explain why the system allowed the error or why inspection missed it. Define the failure mechanism, its scope and the evidence needed to confirm a corrective action.

27 / A 100-PIECE TEACHING INCIDENT

Contain the lot and make the quantities reconcile

Status is attached to identified pieces and quantities, not merely to a folder named "quarantine".

70	18	12
SUPPLIER	IN TRANSIT	CUSTOMER

Initial location / status	Quantity	Required control
At supplier	70	Physically identify and block release.
In transit	18	Coordinate an authorized stop or hold at receipt.
At customer	12	Notify the designated contact; identify and assess affected stock/use.
Total affected lot L-042	100	Retain one reconciled identity/status register.

After all 100 pieces are accounted for and evaluated by the approved sorting method, suppose 88 meet every release requirement, 5 are eligible for approved rework, 4 are assigned to scrap, and 3 remain unresolved. The ledger is 88 + 5 + 4 + 3 = 100. A pending rework is not released stock.

If four of the five reworked pieces later pass and one is scrapped, the final ledger becomes 92 released + 5 scrap + 3 HOLD = 100. Link each transition to identity, action record, verification and authority. Do not count a reworked piece once in its old group and again in its new group.

> **COMMUNICATION IS PART OF CONTAINMENT**
>
> Document which customer/location received the affected identities, what control was requested, who confirmed it and what remains open. This teaching workflow does not authorize a real recall or customer notification by itself.

28 / DEFINE THE PERMITTED ROUTE AND RE-VERIFICATION

Rework changes more than the failed feature

A passing value after rework is necessary but may not be sufficient to close the discrepancy.

Original discrepancy + credible collateral effects + release authority.

Proposed IB-80 action	Affected requirements to re-evaluate
Finish the mounting face	Flatness, total thickness, datum-derived location/orientation, surface texture and any finish/protection affected.
Remove the local burr	Edge limits, adjacent thread or seat, debris, cleanliness and visual acceptance.
Strip and reapply a finish	Dimensions, substrate condition, masking, appearance, process records and permitted repeat processing.
Re-identify/repack pieces	Identity continuity, status segregation and the correct released quantity.

For a feasibility screen, suppose a plate is 15.020 mm thick and a proposed route removes 0.040 mm uniformly. Nominal thickness becomes 14.980 mm, within 14.950-15.050. If the actual final measurement later reports y = 14.980 with U = 0.006, its measurement interval is 14.974-14.986. That U is not a machining-process prediction interval. Nominal arithmetic alone does not prove final size, flatness or other affected requirements.

The rework instruction must identify the affected pieces, allowed operation, requirements to preserve, inspection scope and approving authority. Retain before/after records. Reinspection should cover both the original discrepancy and credible collateral effects; do not merely reprint the original report with a green cell.

> **CLOSE THE SYSTEM ISSUE SEPARATELY**
>
> Repairing five parts does not prevent the next five from failing. Confirm the cause and verify the effectiveness of the process or inspection change on appropriately representative follow-up work.

29 / THE FINAL HANDOFF

Release the evidence package with the actual shipment

The last review should be a reconciliation, not a hunt for whichever PDF is newest.

Package element	Check before release
Identity index	PO/line, part/revision, delivered quantity, serials/lot and packing-list correspondence.
Requirement and report register	Controlled drawing/model and acceptance-plan issues; correct reports for the actual supplied pieces.
Material/process records	Required evidence matches the relevant stock and treatment identities.
Inspection and test results	Scope, methods, statuses and linked sub-results are complete; pending checks remain visible.
Exceptions and dispositions	Only authorized deviations are included, with exact scope and customer requirements satisfied.
Packaging and preservation	Surfaces, threads and identity markings are protected by the agreed method.

An original teaching folder index might contain: 01_Release_Index, 02_Configuration_Register, 03_Material_Process_Records, 04_Inspection_Results and 05_Dispositions. These labels are an organization example, not required filenames. The important feature is a controlled index that maps records to pieces and identifies superseded versions.

Record who reviewed and authorized the shipment, when, against which requirements and for what exact quantity. A release statement must not silently include the three HOLD pieces from page 29. If some records are unavailable, use the approved exception process rather than a note that they will arrive later.

> **KEEP THE CUSTOMER-FACING PACKAGE USABLE**
>
> Provide searchable, legible records with units and identifiers. Do not replace a real measurement record with a photograph of a screen, or strip the report header that establishes the measurement conditions.

30 / WORKED CUSTOMER-TO-SUPPLIER WORDING

A completed inspection request to send with the drawing

Use the structure, but attach the real controlled documents and agree feasibility before production.

WORKED WORDING

To: ruofan@ruojufanxing.com
Subject: IB-80 Rev A - prototype inspection and release scope

Hello vetcnc team,

Please review the attached IB-80 Rev A drawing/model and characteristic register for three identified prototype pieces. We need individual results for all dimensional characteristics on each piece, including each repeated mounting hole. Please propose suitable methods and flag any uncertainty or access limitation before machining.

Dimensions and interfaces are to be verified in the delivered condition after the approved process route. Please confirm the datum/feature evaluation, bore coverage, thread gauging and usable-depth method, texture procedure, and the protected-surface checks.

Our proposed decision rule is DR-01, attached for technical agreement. Identify the measurement uncertainty basis for borderline quantitative decisions. Preserve actual results; do not round values to force acceptance or substitute a different rule without agreement.

Please provide the material/process identity records, dimensional and attribute reports, and an index linking them to the supplied pieces. Flag missing evidence, HOLD items and nonconformances separately. No rework or use-as-is concession is authorized by this email.

Confirm the received revision, proposed inspection scope, added cost and schedule effect before we release the order.
[Name / company / technical contact]

DR-01, SR-01, FIN-IB80 and ED-01 are teaching document names, not attached controlled procedures. A real inquiry must include the actual definitions or clearly identify them as open items for agreement. A reference to a missing document does not specify the requirement.

THE USEFUL SUPPLIER RESPONSE

A feature-by-feature feasibility and evidence proposal is more valuable than a blanket "all tolerances OK." Resolve the open technical choices before they become shipment disputes.

31 / A COMPACT RELEASE-REVIEW DESK CARD

Ten checks before you accept the report

Use this review in addition to, not instead of, the actual product and contract requirements.

Check	Question to close
01 / Identity	Is this the exact part, revision, serial/lot and delivered condition?
02 / Coverage	Are all applicable requirements and repeated features accounted for?
03 / Interpretation	Do datum, size, form, texture and thread definitions match the drawing?
04 / Method	Is the setup and method suitable for the feature and required decision?
05 / Numbers	Are units, limits, corrections, raw precision and relevant uncertainty clear?
06 / Rule	Was the conformity rule agreed and applied consistently?
07 / Evidence	Do material, process and inspection records link to these pieces?
08 / Exceptions	Are failures, HOLD items and approved deviations distinct and resolved?
09 / Quantity	Do released, rework, scrap and pending quantities reconcile without duplicates?
10 / Authority	Is the release scope explicit and approved by the responsible person?

Three claims worth challenging

"The gauge is calibrated, so the result is exact." "Twenty samples passed, so all two hundred pieces are good." "The average is in tolerance, so the feature passes." Each replaces a missing definition or evidence item with confidence. Ask for the actual method, population and characteristic behind the claim.

> **THE DESIRED OUTCOME**
>
> A clear, traceable release decision with known scope, not a larger pile of reports. Use the next two worksheets to record the agreement and any exception; attach the detailed evidence rather than squeezing it into a text box.

APPENDIX A / REUSABLE WORKSHEET

Your inspection and acceptance agreement

Summarize the agreement; attach the detailed characteristic register, method definitions and approved decision rule.

Part / revision / order / quantity

Piece identity / lot boundaries

Characteristics / inspection scope

Final condition / restraint / temperature

Methods / programs / equipment

Decision rule / uncertainty basis

Frequency / sampling scheme

Required records / traceability

Open technical choices, owners and required closure evidence

- [ ] Scope and decision rule are agreed before inspection.
- [ ] Release authority and exception handling are defined.

Save and reopen in a form-capable PDF reader. These fields do not transmit data. Attach longer controlled records separately.

APPENDIX B / REUSABLE WORKSHEET

Your nonconformance and closure record

Record the facts and link the evidence. This worksheet is not an approval to rework, repair, scrap or ship.

NCR / part / revision / affected identities

Characteristic / requirement / limit

Actual result / method / uncertainty

Containment / locations / quantities

Cause status / investigation evidence

Proposed disposition / approving owner

Required re-verification / linked results

Released / scrap / rework / HOLD counts

Closure evidence, approval reference, date and remaining open items

- [ ] All affected identities and quantities are reconciled.
- [ ] Closure covers the original issue and affected requirements.

Save and reopen in a form-capable PDF reader. These fields do not transmit data. Attach longer controlled records separately.

REFERENCE REGISTER / 1

Primary sources and their scope

Publisher records checked 20 September 2026. Linked titles open the source; examples and graphics are original.

[01] ASME

Y14.5-2018 (R2024) - Dimensioning and Tolerancing

Publisher record and public scope. Use the full agreed standard for datum, size, form and position interpretation; this guide is not a substitute.

[02] NIST

Metrological traceability - policy and FAQ

Traceability is a property of a measurement result with a documented calibration chain and uncertainty, not an endorsement of a product or supplier.

[03] NPL

GPG 80 - Fundamental Good Practice in Dimensional Metrology

Foundational guidance for measurement conditions and practical error sources. Legacy examples do not establish current contractual requirements.

[04] NPL

GPG 41, Issue 2 - CMM Measurement Strategies

2014 guide: alignment, holding, probing, sampling and program control. No universal point count or machine capability is adopted here.

[05] NPL

GPG 130 - CMM task-specific measurement uncertainties

2013 technical reference on evaluating the measurement task. Machine verification is not a task-specific uncertainty certificate.

[06] NIST

Engineering Metrology Toolbox - dimensional FAQ

Reference-temperature and calibration context. The thermal coefficients and scenarios in this guide are explicit teaching assumptions.

[07] NIST

TN 1297, Appendix A - Law of propagation of uncertainty

Foundational formulas for a mean, standard uncertainty and propagation including covariance. Original numerical examples are not calibrated results.

REFERENCE REGISTER / 2

Primary sources and their scope

Publisher records checked 20 September 2026. Linked titles open the source; examples and graphics are original.

[08] NIST

TN 1297, Section 4 - Type B evaluation

Conversion of stated uncertainty and bounded inputs to standard uncertainty. Distribution choices require evidence; not every bound is rectangular.

[09] NIST

TN 1297, Section 6 - Expanded uncertainty

Relationship U = k uc and conditions for an approximate coverage interpretation. A k value alone does not prove a coverage probability.

[10] BIPM / JCGM

JCGM 106:2012 - Uncertainty in conformity assessment

General framework for conformity assessment and measurement uncertainty. The three-way rule in this guide is a stated teaching agreement.

[11] ISO

ISO 14253-1:2017 - Decision rules for GPS inspection

Public scope and edition record. Do not equate this guide's symmetric k=2 interval example with every default in this standard.

[12] ISO

ISO 21920-2:2021 - Profile surface-texture parameters

Public scope, corrected version and revision status. The catalogue lists revision work; use the edition actually agreed for the drawing and evaluation.

[13] SAE International

AS9102C - Aerospace first article inspection requirements

June 2023 publisher record and scope. The original worksheets here are not AS9102 forms and do not demonstrate compliance or certification.

[14] NIST / SEMATECH

Kinds of lot acceptance sampling plans

Sampling-plan risks and operating characteristic concepts. No standard-table sampling plan is reproduced or prescribed.

REFERENCE REGISTER / 3

Primary sources and their scope

Publisher records checked 20 September 2026. Linked titles open the source; examples and graphics are original.

[15] R Core / stats

The hypergeometric distribution

Primary software documentation for sampling without replacement. The lot-size examples are original, with perfect classification explicitly assumed.

[16] ISO

ISO 2859-1:2026 - Attribute inspection sampling schemes

Edition 3, published January 2026, replaces the 1999 edition. Public scope only; sample sizes and switching rules need the full agreed scheme.

[17] NIST / SEMATECH

Gauge R&R studies - important issues

Measurement-process repeatability, reproducibility, stability, bias and study design context. Five repeated readings are not a complete R&R; study.

[18] NIST / SEMATECH

What is process capability?

Cp and Cpk definitions and stable-process/distribution assumptions. No universal acceptance threshold or defect-rate guarantee is claimed.

[19] NIST / SEMATECH

Assessing process stability

Stability precedes capability interpretation. Do not turn a short first-article report into a production capability study.

[20] ILAC

Guidance register - G8 and related documents

Public register identifies G8:09/2019 on decision rules and statements of conformity. Refer to the actual applicable guidance and contract, not this register alone.

Standards catalogue pages establish public scope and edition context, not access to every requirement. Use the full contractually agreed documents. NIST and NPL educational references support principles; their examples and service capabilities are not vetcnc production guarantees or endorsements.

CALCULATION DESK REFERENCE

Keep the formulas attached to their assumptions

Use the cited worked page before applying a formula to a new part or measurement process.

Expression	Meaning / limits	Page
Mean = sum(xi) / n	Same defined quantity; do not average away actual feature variation.	12
s = sqrt[sum((xi - mean)^2) / (n - 1)]	Sample standard deviation; a measure of spread, not all uncertainty.	12
u mean = s / sqrt(n)	Independent repeats of a stable measurand; reported result is the mean.	12-13
uc = sqrt[sum(ui^2)]	Contributions already in output units; no covariance in this simplified model.	13
U = k x uc	Coverage needs justification; do not equate k=2 with exact 95% by habit.	13
PASS: y-U >= LSL; y+U <= USL	The guide's agreed two-sided interval rule, not every contractual rule.	14-16
P(zero) = C(N-D,n) / C(N,n)	Random sampling without replacement; D fixed nonconforming units and perfect detection.	24
Cp = (USL-LSL)/(6 sigma)	Stable-process spread relative to tolerance; does not address centering.	25
Cpk = min[(USL-mu)/(3 sigma), (mu-LSL)/(3 sigma)]	Assumed stable model; estimation method and data adequacy matter.	25

Terms: y = corrected result; u = standard uncertainty; U = expanded uncertainty; k = coverage factor; LSL/USL = specification limits; mu/sigma = process mean/standard deviation; N = lot size; D = actual nonconforming count; n = sample count; C = combinations.

THREE QUANTITIES THAT ARE NOT INTERCHANGEABLE

Tolerance is a requirement on the product. Uncertainty describes knowledge of a measurement result. Process variation describes differences across production. Keep their purpose, units and assumptions explicit.

Sources: [07] NIST | [09] NIST | [15] R Core / stats | [18] NIST / SEMATECH

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CNC MANUFACTURING

FROM A DRAWING TO A REVIEWABLE RELEASE

Ask for the evidence your part actually needs.

Send the current drawing and explain which interfaces matter. Agree the measurement scope, decision rule and required records before the first shipment.

01 **DEFINE**

Part revision, final state, characteristic and acceptance requirement.

02 **MEASURE**

Suitable method, traceable identity, actual result and uncertainty basis.

03 **RELEASE**

Resolved exceptions, reconciled quantities and explicit authority.

---

vetcnc.com

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