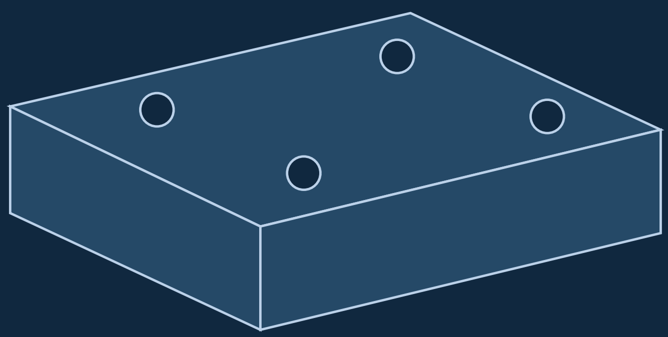
vetcnc
CNC MANUFACTURING

ENGINEERING RESOURCES / 06

CNC Prototype to Production

A Practical Guide

Move from a successful sample
to controlled low-volume delivery.



01 DEFINE

02 DEMONSTRATE

03 RELEASE

A COMPLETE LAUNCH CASE

EVIDENCE-BASED GATES

FILLABLE WORKSHEETS

V1.0 / SEPTEMBER 2026

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START HERE

Use this guide at the handoff

For engineers, buyers and quality teams moving custom machined parts from successful samples to repeat orders.

A prototype can prove that a design is worth pursuing while leaving the production route largely untested. This guide helps you define what must remain the same, what will change, which evidence is missing and who can authorize the next step. It is a practical project workbook, not a claim of certified production readiness.

Read a case, then replace its assumptions

The MB-90 case, measurements, identifiers, schedules and outcomes are fictional, created for this guide. They are not Vetcnc customer records or quoted manufacturing limits. All dimensions are millimeters unless stated otherwise. Acceptance requirements in the case are deliberately limited so the reasoning remains visible; an actual drawing and purchase order must define the complete product.

> **MAKE THE EVIDENCE PROPORTIONAL**
>
> Use more rigorous planning where failure consequences, new processes or contractual obligations justify it. Apply the agreed standards and customer requirements in full. The three worksheets organize decisions; they do not replace drawings, test reports, approvals or regulated validation.

01 / PRODUCTION READINESS

Four decisions, not one approval

Separate product function, process repeatability, release of a lot and permission to reorder.

01 DESIGN	→	02 PILOT	→	03 LOT	→	04 REORDER
Intended function		Defined route		Identified parts		Current baseline

Gate 1 asks whether the released design meets its intended use. Assembly, loading, environment and service life may require evidence that a dimensional inspection cannot provide. Gate 2 asks whether the intended manufacturing route can repeatedly produce that design under stated operating conditions. Gate 3 asks whether a particular lot has the records and conformance evidence required for shipment. Gate 4 asks whether the next order can use the same baseline or needs review.

Decision	Minimum question to resolve	Typical authority
Design release	Does the design work for the agreed use?	Design owner / customer
Pilot-to-launch	Is the proposed route sufficiently demonstrated?	Manufacturing + quality + customer as agreed
Lot release	Are this lot and its evidence acceptable?	Authorized quality / contractual release owner
Repeat order	Is the approved configuration still applicable?	Planning + quality; customer for relevant changes

A buyer can place an order without approving a technical deviation. A machinist can correct a setup without changing a drawing. A quality reviewer can hold shipment even when the schedule is late. Put those boundaries into the project agreement so commercial urgency does not silently become engineering authority.

USE A NAMED STATUS

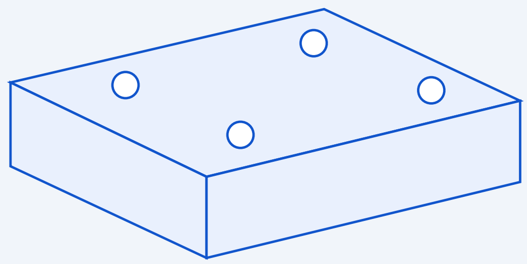
Choose HOLD, RELEASE or a precisely bounded CONDITIONAL RELEASE. State the affected activity, part population, effective date and approver. A green project slide without an identifiable record is not a usable release decision.

Sources: [01] AIAG | [02] SAE International | [11] ISO

02 / CASE DEFINITION

The MB-90 introduction case

A mounting body for an indoor test fixture: three prototypes, a controlled pilot and a first order of 100 accepted parts.



CONTROL THE FINAL FREE-STATE PART

MB-90 / MOUNTING BODY

Nominal envelope: 90 x 60 x 25
K1: height 25.000 +/- 0.050
K2: drawing-defined hole interface

Schematic only; not a released drawing.

The customer has assembled three Rev B prototypes into a non-safety-critical benchtop fixture. Those prototypes were made with one-off workholding and engineer-assisted adjustments. The next purchase requires 100 accepted Rev B bodies, made on a repeatable two-operation route, with a documented dimensional report and lot identity. No aerospace, medical or automotive approval scheme is assumed.

Case item	Controlled project assumption
Material / condition	6061-T6 aluminum; procurement specification, product form and certificate agreed before cutting. No automatic substitution.
K1 mounting height	25.000 +/- 0.050, measured from the defined base to the mounting face after unclamping and conditioning.
K2 hole interface	Hole pattern and mating fit per released drawing; verified by the approved dimensional method and assembly check.
Surface / delivery	As-machined with drawing-defined edge treatment and cleaning; no coating in this baseline.
Quantity boundary	Pilot and investigation pieces are not part of the 100-piece delivery order.

The case investigates a setup-related height shift, not every possible failure mode. The figures are explanatory schematics, not production drawings. A real project must also specify every hole, thread, tolerance, surface, edge and cleanliness criterion needed for acceptance. The later coating example is a separate proposed change and is not silently added to Rev B.

03 / REQUIREMENTS

Translate function into release evidence

Write observable criteria before the supplier starts the pilot.

Start with the function that would be lost, then identify the controlling requirement, method and evidence owner. Avoid requirements such as "high precision", "good finish" or "same as sample" without a defined reference. A retained sample can clarify appearance only within an agreed scheme; it cannot resolve an inconsistent drawing and CAD model.

Need / risk	MB-90 evidence agreed for launch	Who resolves a gap
Mounting height / misalignment	K1 value for each pilot part; final free-state measurement; drawing tolerance and decision rule identified.	Design + quality
Mating interface / interference	K2 report and assembly check on identified final-state samples; fixture revision recorded.	Design owner
Material / wrong stock	Certificate linked to incoming stock and traveler; identity maintained through cut blanks.	Purchasing + quality
Edges / handling damage	Specified edge criteria, controlled deburr instruction and final visual inspection.	Manufacturing + quality
Repeatability / setup dependence	Independent setup records, operators, tool state and ordered results retained.	Manufacturing
Delivery / insufficient output	Capacity calculation and external-process commitments, with time reserved for review.	Planning + buyer

Resolve conflicts before release

For example, the model may show a nominal 25.00 height while an old PDF allows a different range. Ask the design owner which record controls; do not average the requirements or assume the newest email overrides a signed revision. Record precedence, superseded files and the effective order. Confirm whether requirements apply before or after finishing, in a clamped state or free state, and at what conditioning state.

> **AN EVIDENCE GAP IS A DECISION**
>
> If a required functional test is unavailable, record the gap and its consequence. More dimensional measurements do not substitute for the missing functional test. Obtain the appropriate decision before expanding the release scope.

Sources: [11] ISO

04 / BASELINE CONTROL

Freeze a usable configuration

The drawing is only one item in the production baseline.

A production baseline links the design to the exact route and verification method that generated the evidence. Record revision identifiers for documents that affect the result, rather than relying on filenames such as final, latest or approved-new. Keep obsolete records for traceability but remove them from the active point of use.

MB-90 baseline item	Initial pilot	Revalidated route
Product drawing / CAD	MB-90 Rev B / model B	Unchanged
Route / setup instruction	RT-90-01 / SI-90-01	RT-90-02 / SI-90-02
Fixture / jaw assembly	FX-90-A	FX-90-B
NC / setup parameters	NC-90-07 / approved offset rules	NC-90-07; offsets reset and verified
Inspection / control plan	IP-90-02 / CP-90-01	IP-90-02 / CP-90-02
Evidence record	PIL-01: stopped at 16 parts	PIL-02: 24 new pieces
Change authority	Pilot plan PP-90-01	EC-90-01 + revised plan PP-90-02

In this example the corrective action changes workholding and the process instruction, not product geometry. The drawing stays Rev B. The change record explains why the NC file is unchanged, which offset and setup verifications are repeated, and why earlier evidence is not enough. A changed process can need fresh evidence even when the drawing number does not change.

Preserve the released file, its identifier, approval, effective lot and storage location. A checksum can detect that bytes changed but does not say whether a file was technically approved. Restrict editing of released programs and instructions through the supplier's normal access controls; do not put uncontrolled USB copies into the release package.

FREEZE DOES NOT MEAN NEVER CHANGE

It means changes become visible and authorized. Define how emergency corrections, program edits, supplier substitutions and temporary deviations enter the register and how affected inventory is identified.

Sources: [04] ISO

05 / PROCESS DEFINITION

Compare the actual process routes

A successful one-off method is evidence about that method, not every future production method.

SAMPLES	ONE-OFF SETUP →	ASSISTED CUT →	BENCH CHECK
REPEAT	RELEASED SETUP →	CONTROLLED RUN →	LOT RELEASE

Prototype condition	Production question	Evidence to request
Engineer hand-fits the part	Can the standard route meet the print without individual correction?	Record all manual adjustments and approved rework steps.
One vise / one operator	What changes after a complete teardown and setup?	Fresh setup trials with ordinary instructions.
New tool throughout	What happens near the intended replacement point?	Tool-state record and controlled life study.
Immediate bench inspection	Will the normal measurement and release queue work?	Timing, conditioning, method and staffing records.
No shipment handling	Will parts remain conforming in transit and storage?	Agreed packaging and receiving checks.

Walk the part through the real sequence: receipt, sawing, OP10, transfer, OP20, deburr, clean, condition, inspect, segregate and pack. Include external operations and temporary storage. At each handoff ask what identity is retained, what can be damaged or mixed, and how the next person knows the preceding step is complete.

NAME THE MANUAL WORK

A route is not automated merely because the cutting cycle is CNC-controlled. Loading, chip removal, offset entry, deburring and inspection can dominate repeatability. Make these steps executable by the intended operators and include their time in capacity planning.

Sources: [09] Renishaw

06 / RISK REVIEW

Turn risks into actions

Use a short working register first; use the customer-required PFMEA method where it applies.

Write the failure mode, customer effect and plausible cause as separate statements. "Operator error" is not an adequate final explanation when the fixture accepts a reversed part or the instruction hides a required cleaning step. Identify what prevents the cause and what detects the effect; those are different controls.

Failure chain	Prevention / detection	Action and closure evidence
Chip on locator -> height shift -> assembly mismatch	Relieved seating geometry and cleaning; K1 check after setup.	Validate revised jaw and reloading sequence; retain measured results.
Wrong stock -> wrong properties -> functional risk	Stock segregation and traveler identity; receipt-document review.	Demonstrate certificate-to-blank link before cutting pilot.
Old program -> wrong feature -> mating failure	Released program list and access control; first-off verification.	Compare controller file to approved release and record verification.
Burr retained -> poor seating -> assembly error	Defined deburr method; final edge and fit check.	Train intended operators and challenge inspection using known examples.
Parts mixed after clean -> lost identity -> unverifiable lot	Separated containers and transfer counts; label reconciliation.	Run a mock split and reunion of one lot without losing identity.

Assign an owner and due date to each action. Close it with evidence that the action was implemented and affected the risk, not just a photograph of a revised instruction. For high-consequence features, escalate unresolved risks even when an overall score looks low. This guide does not prescribe an RPN threshold, rating scale or permission to accept a severe risk.

> **REVIEW WHAT ACTUALLY HAPPENED**
>
> Update the risk register after the pilot. An unplanned stop, repeated offset change or missing certificate is new information. Feed it into the route, control plan and next release decision rather than filing it only in meeting minutes.

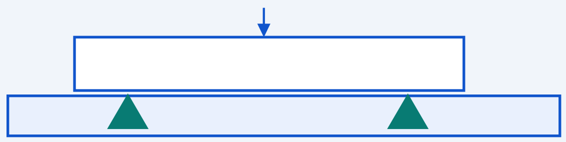
Sources: [10] ASQ

07 / FIXTURE READINESS

Validate locating and clamping

Test repeat loading, setup recreation and the final free-state part.

Separate three questions: can the fixture locate a part, can an operator reproduce the setup, and does the part remain acceptable after unclamping? Repeatedly measuring one clamped part answers none of these completely. A fixture can be repeatable while consistently locating from the wrong surface.



LOCATE / CLAMP / CUT / RELEASE

A seating error can survive a nominal setup check.

Verify the final part after unclamping; record the setup that made it.

Trial	Record	Interpretation
Reload the same part	Operator, clean condition, seating check and repeated measurement.	Screens loading consistency; not manufacturing variation.
Machine fresh parts	Stock identity, clamp sequence, tool state, final free-state results.	Includes cutting and unclamping effects.
Recreate the setup	Remove and reinstall fixture as planned; reset and verify coordinates.	Tests the instruction and setup recovery.
Inspect after release	Conditioning, measurement support, contact points and method.	Detects a result hidden by clamp restraint.

For MB-90, a locator seating check becomes an explicit operation. A force or torque value would need the correct hardware, lubrication state and validated relationship to safe retention; do not copy a generic clamp value into the instruction. Check tool access, collision clearance, chip evacuation and supported surfaces with the actual configuration.

BOUND THE CONCLUSION

Three successful reseatings do not establish performance over all operators, material batches or fixture wear. Record what the trial covers and list untested conditions. Preserve the normal workholding safety checks when conducting any challenge.

Sources: [09] Renishaw

08 / EXECUTABLE PROCESS

Control programs, tools and offsets

The controller should contain an identifiable release, not the only surviving copy of the job.

Build a setup pack that another qualified operator can follow: approved program identifier, machine configuration, work coordinates, fixture orientation, tool assembly list, gauge lengths, allowed offsets, verification steps and restart instructions. Keep the engineering master separate from the released machine copy; log any approved shop-floor edit and reconcile it before the next order.

Control	Useful record	Avoid
NC verification	Released file ID, postprocessor context and verification approval; changes recorded.	Treating a simulation screenshot as proof of every physical setup.
Tool assembly	Tool and holder IDs, projection, relevant runout checks and replacement rule.	Substituting a tool solely because its nominal diameter matches.
Offsets	Who may adjust which offset, by what rule, with what recheck.	Unbounded edits until one inspected part passes.
Restart	Safe recovery sequence after interruption, including part status and coordinate verification.	Resuming at a convenient line without approved recovery logic.
Backup	Retrievable released pack, controller copy and record of revision reconciliation.	A single program stored only on the machine.

In PIL-01 the team must not hide a seating problem by changing the height offset after every setup. Such compensation may produce individual conforming pieces while leaving the underlying locating error uncontrolled. Compare the physical setup to the released instruction first; retain the failed results and any adjustments as part of the investigation.

Define a permitted intervention

An ordinary tool replacement can be a planned event if it uses the approved tool assembly, reset method and first-off checks. A different holder or cutting strategy is not automatically the same event. Classify the change by what it can affect and route it to the appropriate technical owner before routine production resumes.

Sources: [04] ISO | [09] Renishaw

09 / TRACEABILITY

Keep material and lot identity intact

A certificate is useful only when it can be linked to the parts being accepted.

At receipt, reconcile the purchase requirement, supplier description, product form, material condition, lot or heat identity, certificate and quantity. Define who investigates discrepancies. Do not relabel uncertain stock based on appearance or assume that a familiar alloy name makes an undocumented substitution acceptable.

STOCK		BLANKS		TRAVELER		RESULTS
MAT-061	→	BL-061	→	TR-P2	→	P2-001...024

Preserve identity at each split, transfer and disposition.

Event	MB-90 record example	Check at handoff
Receive stock	MAT-061 / supplier lot A / certificate MC-061	Identity and ordered condition agree.
Cut blanks	BL-061 / 24 blanks for PIL-02	Remaining bar and cut blanks stay linked.
Machine / inspect	P2-001 to P2-024 / traveler TR-P2	Part-to-result and route links are retained.
Split for review	P2-001 to P2-008 in container C1	Count, IDs, status and location recorded.
Reunite / disposition	All 24 accounted for; pilot-only status	No pilot part enters the delivery lot.

For small simple orders, part-by-part permanent marking may be unnecessary or harmful. A validated container and traveler method may preserve identity if parts cannot become mixed and the contract permits it. If individual measurement results or selective rework must follow a particular part, use an identification method that survives those operations without damaging a controlled surface.

> **SEPARATE TWO MEANINGS OF TRACEABILITY**
>
> Product traceability links stock, process and delivered items. Metrological traceability links a measurement result to reference standards through a calibration chain. One does not establish the other, and neither alone proves the product meets every requirement.

Sources: [04] ISO | [08] NIST

10 / MEASUREMENT READINESS

Qualify the measurement route

Do this before interpreting a pilot spread or deciding whether a corrective action worked.

For each launch-critical characteristic define the measurand, datum or support arrangement, instrument, program, conditioning, method, recording precision and conformance decision rule. Confirm that the method can distinguish a meaningful process change from measurement variation. Resolution printed on a display is not the same as uncertainty or repeatability.

Readiness question	MB-90 application
Same characteristic?	K1 is final free-state height from the specified base, not a convenient in-machine coordinate.
Same part state?	Deburred, cleaned, unclamped and conditioned using IP-90-02; support must not distort the body.
Consistent people and methods?	Use identified parts across intended operators; retain repeated results, not just average values.
Adequate uncertainty?	Document task-specific suitability and agreed decision rule, including results near a tolerance limit.
Verified program?	Review alignment, probing locations and calculation outputs before using automatic reports.
Usable record?	Part ID, actual value, unit, method revision, operator and time can be traced.

The fictional dataset later in this guide uses a pre-agreed simple comparison to the stated limits for readability. It assumes the measurement method is adequate and that the parties have accepted its decision risk. An actual contract may require guard bands or a different decision rule. If uncertainty is material to a borderline result, obtain the agreed decision instead of rounding the result into tolerance.

> **USE THE RIGHT STUDY**
>
> A repeated reading checks only part of the system. A broader study may need different operators, representative parts, setups and time. Select the design for the decision; do not automatically impose a fixed 10-part study or claim that calibration alone completes measurement-system analysis.

Sources: [08] NIST

11 / TRIAL PLAN

Build a pilot that asks questions

Coverage, stopping rules and evidence are agreed before the first part is cut.

MB-90 plan PP-90-01 schedules six fresh setups with four new pieces per setup: 24 pieces in total. Operators A and B alternate. Each setup includes fixture removal and reinstallation, normal checks and the released route. This is an operational challenge to setup recovery, not a randomized experiment that can isolate an operator effect from time or setup order.

Setup block	Operator / part IDs	Planned challenge
S1 / S2	A: 001-004 / B: 005-008	Initial setup and independent recreation.
S3 / S4	A: 009-012 / B: 013-016	Repeat removal, cleaning, installation and verification.
S5 / S6	A: 017-020 / B: 021-024	Further recovery using the same written instruction.

The first-off in each block is checked before the remaining three pieces are cut. All four K1 results are then reviewed before another block begins. All pilot pieces receive the agreed full inspection. A nonconforming result, unexplained shift, unsafe setup, missing traceability or unauthorized edit triggers a stop and review. No one adds extra good pieces to dilute a failed block.

State what this plan does not cover

The initial plan uses one machine, one stock lot and the same defined tool condition. It does not demonstrate a second machine, material-lot variation, end-of-life tooling or a coating route. Record these limits and handle them through later studies, containment or restricted release. If operator differences need statistical attribution, design a suitable blocked or randomized study separately.

BUDGET FOR A FAILED TRIAL

Reserve stock, machine access and review time for investigation and a repeat. Predetermine whether pilot pieces can ever become deliverable product. Here they cannot. The 100-piece order therefore stays separate from all trial quantities.

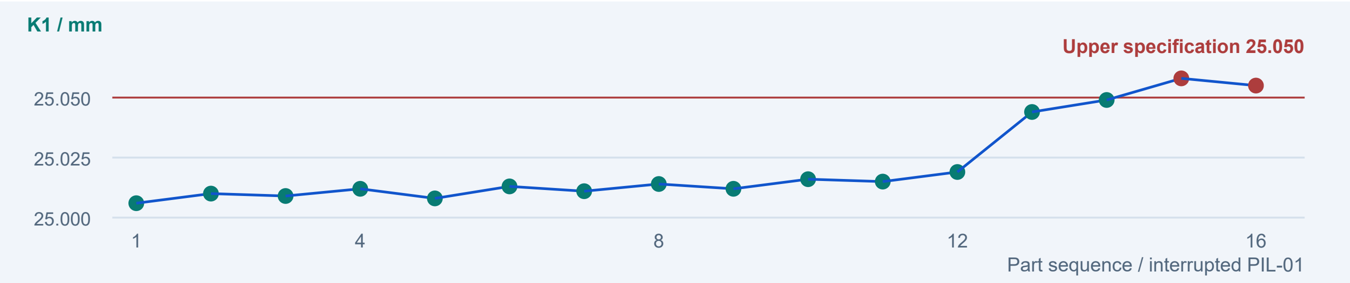
Sources: [07] NIST/SEMATECH

12 / CASE: PIL-01

A pilot that stops at piece 16

The planned 24-piece trial is interrupted. Eight planned pieces are never made on the original route.

Block / operator	K1 results, in part-ID order	Disposition
S1 / A / 001-004	25.006 / 25.010 / 25.009 / 25.012	4 pass
S2 / B / 005-008	25.008 / 25.013 / 25.011 / 25.014	4 pass
S3 / A / 009-012	25.012 / 25.016 / 25.015 / 25.019	4 pass
S4 / B / 013-016	25.044 / 25.049 / **25.058** / **25.055**	2 pass; 2 fail
S5 / S6	017-024: not produced	Canceled after hold



The allowed K1 range is 24.950 to 25.050. Pieces 015 and 016 exceed the upper limit; the other two S4 pieces are conforming under the case decision rule but show a marked shift relative to earlier blocks. S4 first-off 013 passed, so the instruction permitted the next three pieces. The end-of-block review then identifies the failures and stops the trial. There is no claim that every failure was caught before the next cut.

The recorded first-pass K1 result is 14/16 = 87.5% for this interrupted trial. That fraction is not a long-run yield forecast. Quarantine all 16 pieces pending scope review; confirm the measurement method and part identity. Investigate S4 rather than immediately concluding that operator B caused the problem, since B also produced S2 without this shift.

DO NOT REWRITE THE DENOMINATOR

The result is not 22/24, 14/24 or "passed after adjustment". Preserve 16 produced, 2 K1 failures and 8 unmade. Subsequent successful pieces belong to a new, separately identified trial.

13 / CASE: EC-90-01

Correct the cause and retain the failure

Containment protects the current population; corrective action changes the route; revalidation tests the change.

The fictional investigation finds a chip trapped at a locating surface in S4. A retained seating witness, inspection of the fixture and a controlled engineering check support this explanation. A single observation is not enough to prove that every failure has the same cause. The team also reviews clamping, datum transfer, temperature, tool state and measurement setup before closing the investigation.

Step	Recorded action	Release implication
Contain	Hold all PIL-01 pieces; identify S4 failures; preserve results and fixture evidence.	No delivery or general process release.
Verify cause	Check seating mechanism and relevant alternative causes under an approved investigation plan.	Do not fix the diagnosis by changing the acceptance limit.
Correct route	FX-90-B adds appropriate chip relief; SI-90-02 requires seating and cleaning checks.	Review retention, support and tool clearance again.
Update controls	CP-90-02 adds a K1 launch trigger above 25.035 and a defined response.	Trigger is stricter than tolerance, not a new specification.
Repeat evidence	PIL-02 uses 24 new pieces over six recreated setups.	Close only the conditions actually demonstrated.

The 25.035 launch trigger is a conservative project choice made after the failure, not a statistical control limit. State that distinction on the control plan. Its role is to stop an emerging shift earlier while the route is being learned; a part between 25.035 and 25.050 is not automatically defective, although its process condition needs review.

KEEP AN HONEST HISTORY

The revised instruction and fixture are separate revisions. Do not replace PIL-01 values with remeasured or reworked values. Preserve original results, investigation records, the authority for each disposition and the link to the new trial.

Sources: [12] NIST/SEMATECH

14 / CASE: PIL-02

Revalidate the changed route

Twenty-four new parts, six recreated setups, two operators and an explicit boundary on the conclusion.

Block / IDs / operator	Four K1 values	Mean
R1 / 001-004 / A	25.008 / 25.011 / 25.010 / 25.013	25.01050
R2 / 005-008 / B	25.012 / 25.015 / 25.014 / 25.016	25.01425
R3 / 009-012 / A	25.010 / 25.014 / 25.012 / 25.015	25.01275
R4 / 013-016 / B	25.016 / 25.019 / 25.017 / 25.020	25.01800
R5 / 017-020 / A	25.011 / 25.014 / 25.012 / 25.016	25.01325
R6 / 021-024 / B	25.018 / 25.021 / 25.019 / 25.023	25.02025

Across these 24 fictional measurements, the minimum is 25.008, maximum 25.023 and overall mean 25.015 when rounded to 0.001. Extra digits in the block means show arithmetic, not better measurement resolution. All values are within the drawing limits and below the launch trigger. The agreed full inspection, K2 assembly check, edges, cleaning and material identity also passed in the case; a real package needs those detailed attachments, not an inference from K1.

Decision: bounded launch, not unlimited approval

The project team accepts PIL-02 as support for a controlled first order on the listed machine, fixture and route. The approval requires 100% K1 checks for the first order, first-off review after interruptions, specified tool-change checks and complete lot reconciliation. It does not authorize a second machine, coating process, unknown stock or removal of the launch controls.

Both successful and failed trial records stay in the package. The difference between PIL-01 and PIL-02 is not summarized as "the process is now statistically capable". The route was corrected and the planned operational coverage passed, but the sample is too limited to support sweeping reliability or process-distribution claims.

> **SEPARATE FACTS FROM EXTRAPOLATION**
>
> Observed: 24 pieces passed the stated trial checks. Authorized: one bounded launch route. Not established: a universal defect rate, all material lots, indefinite tool life or a machine-to-machine equivalence claim.

Sources: [05] NIST/SEMATECH | [07] NIST/SEMATECH

15 / NUMERICAL DECISION AID

What zero failures can and cannot say

An all-pass pilot is useful evidence, but the sample size limits what it can demonstrate.

Suppose each tested item independently has the same unknown probability p of failing a defined check, and detection is perfect. The probability of observing zero failures in n items is (1 - p)^n. Setting this probability to 0.05 gives a one-sided 95% upper confidence bound pU = 1 - 0.05^(1/n). These are model assumptions, not facts established by a CNC pilot.

Zero failures in n	One-sided 95% upper bound	Interpretation under the model
3	63.16%	Three successful prototypes are weak rate evidence.
24	11.73%	An all-pass small pilot cannot demonstrate a 1% failure ceiling.
100	2.95%	More evidence, but still not a 1% upper bound.
299	1.00% (rounded)	Exact bound is just below 1%; requires zero failures.

To obtain an upper bound at or below a chosen p0 with zero failures, use n >= ln(0.05) / ln(1 - p0), then round up. For p0 = 0.01, the result is 298.073, so at least 299 independent observations are required. This is a confidence-bound demonstration calculation, not a recommended production run size or a lot-acceptance sampling plan.

Why the case cannot simply use this as a certificate

The 24 case parts are grouped by setup, produced on one route and selected to challenge specific conditions. Shared setup errors can correlate outcomes. The process also changed between trials. Pooling PIL-01, PIL-02 and prototypes as if they were independent, identical trials would hide these distinctions. Functional life, fatigue or field reliability need their own defined failure event and exposure model.

READ CONFIDENCE CORRECTLY

A frequentist 95% confidence procedure has a long-run coverage interpretation; it does not assign a 95% probability to a fixed unknown p after this one sample. Use the calculation to expose weak evidence, not to turn an arbitrary sample size into a guarantee.

Sources: [06] NIST/SEMATECH

16 / LAUNCH CONTROL

Write a control plan people can use

Link the characteristic, method, frequency, record and reaction in the same row.

A practical launch control plan tells an operator what to do and a reviewer what evidence to expect. Keep it consistent with the route and inspection plan. Distinguish a product acceptance requirement from an internal process trigger; otherwise the team may either ship an unacceptable part or unnecessarily reject a conforming one.

Control item	Case frequency / record	Reaction
Material identity	Every incoming lot and each split; certificate / traveler link.	Hold uncertain population; reconcile source before use.
Fixture seating	At every load, per SI-90-02; setup sign-off and event log.	Stop if seating cannot be verified; clean and recheck.
K1 height	Every first-order part, final state; value by ID. First-off before continuing; no more than 12 pieces awaiting review.	Hold process for value >25.035; nonconforming outside 24.950-25.050.
Other drawing features	First-off and approved feature-specific plan; final report.	Contain affected interval; evaluate all related requirements.
Tool event	Before use and after replacement; tool ID / reset check.	First-off review before routine cutting resumes.
Edges / clean / pack	Each delivered part and container; status checklist.	Segregate, correct by approved method, reinspect.

The example frequencies are project choices, not standard requirements for every CNC job. Define a response for both high and low shifts if both can arise; here the added 25.035 trigger addresses the demonstrated positive seating shift, while the drawing lower limit remains mandatory. A broader drift-detection rule would need separate justification.

> **A TRIGGER MUST HAVE AN OWNER**
>
> Specify who stops production, where held material goes, who determines the suspect interval and who permits restart. A red cell with no assigned action is not an effective control.

Sources: [01] AIAG | [11] ISO | [12] NIST/SEMATECH

17 / WEAR AND INTERVENTION

Tool life is a route condition

A successful trial with a fresh cutter does not prove the last part before replacement.

Track the tool or cutting edge that creates a sensitive feature. Relate usage to a meaningful exposure: parts, cutting time, cutting length or another justified measure. Record resets and replacement events. Do not allow a counter reset to erase wear history when a used tool is returned to the machine.

Study element	Useful evidence	Release question
Beginning / middle / end	Ordered results, tool exposure, edge condition and relevant process observations.	Does the chosen replacement point retain margin?
Tool-to-tool variation	More than one identified tool assembly under comparable conditions.	Was the result specific to one unusually good cutter?
Replacement recovery	Presetting, offset verification and new first-off record.	Can normal operators recover the route?
Unexpected damage	Breakage or chipping event and affected-part interval.	Which parts need containment and reinspection?

For the case launch, the team initially restricts the critical finishing tool to short, explicitly controlled service intervals until a separate life study is complete. The actual interval is set by the project evidence, not supplied by this guide. Budget the replacement and first-off time. If a tool is changed more often during the pilot than it will be in production, mark that as an untested difference.

Do not compensate away a failure mechanism

A wear offset can manage a known size trend within an approved rule. It does not repair edge chipping, chatter, poor seating or a change in surface integrity. Record offset history and the reason for intervention. A steady stream of adjustments can be important evidence even when the resulting dimensions remain within tolerance.

> **NO UNIVERSAL LIFE NUMBER**
>
> Do not turn a toolmaker recommendation into a guaranteed number of parts. Material condition, engagement, coolant, holder, machine and interrupted cutting can change the result. Verify the intended combination and define what invalidates the study.

Sources: [09] Renishaw

18 / STABILITY AND CAPABILITY

Use small-lot data honestly

A pilot is a learning run before it is a statistical claim.

Keep results in time and part-ID order. Stratify by setup, machine, tool, operator and relevant material batch before pooling. A single average can conceal a setup shift. A histogram can show spread but loses sequence; a run chart preserves sequence but is not automatically a statistical control chart.

Statement	What would justify it	What does not
These parts passed	Identified requirements, suitable measurements and the agreed decision rule.	The batch average lies near nominal.
The process appears stable	Appropriate time-ordered evidence and a justified monitoring method.	All pilot points happen to be within tolerance.
The route is capable	Suitable stability evidence, distribution and sampling assumptions, estimation method and uncertainty.	A very high Cpk from a few selected good pieces.
The next lot is acceptable	The agreed release evidence for that lot, plus applicable approvals.	A capability number from an earlier revision.

NIST frames capability as comparison of an in-control process with specification limits. In the MB-90 case, six small setup blocks are kept visible. The guide reports observed values and operational coverage instead of publishing Cp or Cpk. This avoids giving a precise-looking index more authority than the trial supports.

If a customer requires a capability submission, agree the characteristic, study plan, subgrouping, within-versus-overall variation method, handling of tool changes and minimum evidence with the reviewer before the run. Do not borrow a sample-count rule or acceptance threshold from an unrelated industry. Explain limitations when the volume or destructive testing makes the requested study impractical.

LIMITS MEAN DIFFERENT THINGS

Specification limits come from product requirements. Control limits are estimated for a defined monitoring method. A launch trigger is a project intervention rule. Label each correctly; moving a control limit never changes the drawing tolerance.

Sources: [05] NIST/SEMATECH | [12] NIST/SEMATECH

19 / WORKED CAPACITY MODEL

Calculate capacity beyond cycle time

First order: 100 accepted bodies; one machine; no overtime assumed.

Assume a planning yield of 96%, 12 minutes of total machine occupancy per start across both operations, 120 minutes for setup and first-off work, and 30 minutes reserved for planned tool events. There are 420 available production minutes per day after separately listed breaks and other committed work. These are original planning assumptions, not Vetcnc performance data.

Step	Calculation	Result
Starts to plan	ceil(100 / 0.96)	105 starts
Running occupancy	105 x 12 min	1,260 min
Machine requirement	1,260 + 120 + 30	1,410 min
Available in 3 days	3 x 420	1,260 min
Nominal 3-day shortfall	1,410 - 1,260	150 min
Days of nominal capacity	1,410 / 420	3.36 days; book 4
With 10% availability loss	420 x 0.90 = 378; 1,410 / 378	3.73 days; still book 4

Rounding up expected starts is not a guarantee of 100 good parts. Actual scrap may be higher; define how shortages trigger extra approved starts and a revised schedule. Do not count the pilot pieces as free capacity or deliverable inventory. If the 12-minute occupancy already includes certain checks or losses, do not add them again.

Separately, allow 5 minutes of off-machine handling and 6 minutes of inspection per start, plus a 30-minute reinspection reserve: 525 + 630 + 30 = 1,185 labor minutes. Inspecting starts, not only eventual good parts, avoids hiding rejection work. Inspection needs 660/300 = 2.20 days at 300 minutes per day: book three days. This reserve may be exceeded. If one person tends the machine and inspects, model the resource conflicts.

BOOK A ROUTE, NOT A DIVISION

Four machine days do not mean four calendar days to shipment. Material readiness, release review, inspection capacity, outside operations and transport can dominate the calendar. Verify the bottleneck and reserve recovery time.

20 / WORKED LAUNCH CALENDAR

Schedule the gates and the queues

A schedule is a set of dependencies, not only a promised ship date.

D1-D3 / PILOT	D4-D7 / MACHINE	D8-D10 / QA	D11

Freeze before D1. First-order release required before D4.

Case activity	Illustrative window	Dependency / owner
Freeze package and receive stock	Before D1	Customer + purchasing; no unresolved baseline gap.
Pilot plus investigation allowance	D1-D3	Engineering and quality; reserve review time.
Authorize bounded first order	End D3	Named approvers accept evidence and restrictions.
First-order machining	D4-D7	Four booked machine days; controlled route only.
Final inspection and records	D8-D10	Three days reserved; part checks and lot reconciliation.
Release, pack and dispatch	D11	All holds closed and shipping pack complete.

This is a deliberately simple eleven-workday scenario, not a promised lead time. The three-day inspection reservation can partly overlap machining for required first-offs and launch checks; any remainder is completed before release. If PIL-01 fails, revalidation must finish inside the allowance or the schedule moves. Agree who communicates delays and whether a separately approved partial delivery is acceptable.

Parallel work can shorten the calendar only when the dependency genuinely permits it. Packaging preparation may run while machining continues. Final-state inspection cannot be replaced by inspection before a later operation that can change the feature. Cutting the whole lot before pilot approval is an at-risk commercial decision requiring explicit agreement and a clear disposition path.

PROTECT THE DECISION TIME

Reserve time for questions about results, not just test execution. If the customer needs one business day to review the package, include it before dispatch. "Report sent" is not the same as "release received".

21 / FINISHING AND SUBCONTRACTING

An outside process changes the plan

Separate example: the customer proposes anodizing the MB-90 after the original as-machined launch.

A finish added later is not a cosmetic note on an otherwise unchanged route. It can affect final dimensions, mating surfaces, masking, electrical behavior, appearance, cleanliness and the verification sequence. Ask the design owner to specify the required finish and acceptance conditions; do not select a treatment or allowance solely from a generic thickness table.

Interface to control	Question before the trial	Evidence at receipt
Finish specification	Which standard, class/type and revision are contractually required?	Order, process certificate and applicable test reports.
Functional surfaces	Which faces or holes are treated, masked or finished afterward?	Final-state dimensional and functional checks.
Lot transfer	Can identities survive racking, splitting and recombination?	Count and identity reconciliation with processor lot.
Appearance	Which zones and reference conditions govern evaluation?	Agreed final visual inspection, not camera color alone.
Rework / stripping	Who may authorize a repeat treatment and evaluate its effects?	Approved disposition with affected IDs and reinspection.

The production release should identify the approved external route and responsibilities. A processor's certificate can document a specified operation, but it does not automatically verify every final part feature or all upstream material requirements. Determine what is verifiable by final inspection and what needs process-specific qualification, records or customer approval.

DO NOT REUSE THE OLD CONCLUSION UNCHANGED

The earlier as-machined pilot does not demonstrate the coated route. Conduct an impact review and proportionate verification before authorizing shipment. For regulated or customer-controlled special processes, apply the actual required qualification and approval scheme.

Sources: [02] SAE International | [11] ISO

22 / APPROVAL BOUNDARIES

First article is not every approval

Agree the required deliverable by name, edition, scope and submission authority.

A first-off check is an operational checkpoint before continuing a setup. A first article inspection is a documented verification activity with an agreed scope. A production approval process addresses a broader set of evidence and authorizations where required. Avoid using these terms as interchangeable labels on the same spreadsheet.

Deliverable	What it can support	What to agree
First-off record	Continuation of the current setup after defined checks.	Features, trigger events, reviewer and record location.
Generic first article report	Documented conformity for specified product characteristics.	Coverage, format, samples, evidence and deviations.
AS9102 FAI, if required	The contractually specified aerospace FAI activity.	Full applicable revision and customer requirements.
PPAP / production approval	Required approval evidence under the applicable customer scheme.	Submission scope, timing, status and authorized recipient.

SAE AS9102C establishes requirements for performing and documenting aerospace FAI and complements customer and regulatory requirements. SAE AS9145 addresses aerospace APQP and PPAP. AIAG publishes automotive APQP and control-plan guidance. Their public scope pages do not make any of these schemes mandatory for every general machining purchase.

The MB-90 agreement

The customer requires a complete agreed dimensional package and bounded first-order release, not an AS9102 claim or an automotive PPAP warrant. The supplier must not advertise the package as an industry-specific approval it was not prepared to satisfy. If requirements change, resolve the scope and commercial impact before the evidence run.

A REPORT HAS A BOUNDARY

A conforming first article does not alone establish functional life, ongoing process stability, unrestricted capacity or acceptance of every later lot. Identify the specific decision that the report supports and the evidence still required.

Sources: [01] AIAG | [02] SAE International | [03] SAE International

23 / EVIDENCE HANDOFF

Assemble a release packet

Make it possible for someone outside the trial team to reconstruct the decision.

Packet item	MB-90 example	Reviewer checks
Index and status	REL-90-01, revision 1	Every attachment exists and uses the same scope.
Requirements baseline	Drawing B, model B, order scope	No unresolved precedence or acceptance gap.
Route configuration	RT-90-02, FX-90-B, NC-90-07	Evidence matches the proposed production route.
Material / identity	MC-061 and travelers	Parts and results link back to controlled stock.
Trial evidence	PIL-01 and PIL-02 raw results	Failed trial retained; canceled pieces not counted.
Corrective action	EC-90-01 and investigation	Implementation and revalidation are documented.
Measurement records	IP-90-02 and suitability review	Method, part state and decision rule are clear.
Launch controls	CP-90-02 and tool-event checks	Temporary controls and stop/restart owners defined.
Open items / authority	Scope restrictions and signatures	No required item silently treated as complete.

Store records with a durable index and access method. Do not rely on a broken share link or an email attachment with no revision. Reviewers should see both the decision summary and the underlying actual results, including outliers, rework, canceled operations and changes during the trial.

Approval should state the route, quantity or period, excluded conditions, remaining actions and effective lot. A conditional release is useful only if each condition can be checked and enforced. If an open item is essential to product safety or contractual acceptance, a generic "proceed at risk" note is not an adequate substitute for the required authority.

> **MAKE REVIEW EFFICIENT**
>
> Use one index with attachment IDs and a concise decision page. Do not bury the unresolved issue in a hundred pages of nominally green results. The reviewer needs to know what is proven, what is assumed and what remains restricted.

Sources: [04] ISO | [11] ISO

24 / CASE: PRODUCTION LOT L1

Reconcile the first delivery lot

Count starts, first-pass acceptance, rework, scrap and shipment without double counting.

105 → **96 + 4** **5**

STARTED ACCEPTED SCRAP

105 = 96 first-pass + 4 reworked and accepted + 5 scrap.

L1 quantity category	Count	Meaning
Started	105	Separate from prototypes and both pilots.
First-pass accepted	96	Meet all required checks without rework.
Rework candidates	5	Held for authorized deburr correction and full affected reinspection.
Accepted after rework	4	Subset of the 5 candidates; not extra starts.
Scrap	5	4 direct scrap plus 1 unsuccessful rework candidate.
Final accepted / shipped	100 / 100	No unexplained balance; no remaining WIP.

The balance is 105 = 96 first-pass accepted + 4 accepted after rework + 5 scrap. First-pass yield is 96/105 = 91.43%; final acceptance yield is 100/105 = 95.24%. Rework recovery is 4/5 = 80%, a different denominator. Reporting only "100 delivered" conceals the rework and loss that matter for the next order.

The five rework candidates had edge conditions outside the drawing requirement. Their K1 values were acceptable, but this does not make them first-pass conforming parts. Authorized deburring removed the condition on four; one could not meet the final requirement and was scrapped. Keep original findings, rework authorization and final results linked to each ID.

> **QUANTITY IS NOT RELEASE**
>
> A total of 100 apparently good pieces is not sufficient if identity, material evidence or a required approval is missing. Reconcile both physical quantity and release status. Do not ship a held part merely to complete the ordered count.

25 / WORKED RESPONSE

Contain a suspect interval

Separate a process hold from the final disposition of individual parts.

During L1, review of an off-machine inspection batch finds K1 = 25.041 on piece L1-064: within 25.050 but above the 25.035 launch trigger. The last previously reviewed normal record is L1-052. Pieces 053-064, including those still awaiting review, form a twelve-piece suspect interval. The process stops before 065. Here 100% measurement coverage does not mean zero inspection queue; the plan must bound that queue and its exposure.

052
LAST NORMAL

→

053-064
12 SUSPECT PARTS

→

065
RESTART ONLY

Suspect count = 64 - 53 + 1 = 12; investigate before disposition.

The interval is not automatically twelve defective parts. Review the event log, setup changes, measurement method and physical seating. Expand the hold if the evidence cannot justify the boundary. In this fictional event, a seating check is repeated, the affected twelve pieces are all reverified in final state and satisfy every relevant requirement. No rework is needed for those twelve, so they remain part of the 96 first-pass accepted pieces on page 26.

Record	Required content
Hold H-90-02	Trigger value, time, IDs 053-064, location and person stopping the process.
Investigation	Measurement verification, setup evidence, cause assessment and interval justification.
Disposition	Actual recheck results; twelve accepted without rework under authorized review.
Restart	Restored setup checks, approved first-off and restart signature before L1-065.

REINSPECTION IS NOT A RESET BUTTON

A passing recheck must be technically explained if it conflicts with an earlier nonconforming value. Do not repeatedly measure a failed part until a favorable number appears. Here the original 25.041 was already conforming; the hold was a process intervention, not an erased product failure.

Sources: [12] NIST/SEMATECH

26 / CASE: GATE REVIEW

Close the launch with a bounded decision

Shipment approval and removal of extra launch controls are separate decisions.

Evidence reviewed	Case conclusion	Next action
PIL-01 failure / PIL-02 repeat	Corrected route demonstrated under the planned setup coverage.	Retain EC-90-01 in the route history.
L1 quantity and product records	100 accepted, 5 scrap; all identities and reports reconciled.	Authorize shipment of the identified 100.
H-90-02 process hold	Conforming suspect interval released after documented review.	Continue enhanced seating and K1 controls.
Edge rework	5 candidates; 4 recovered; 1 scrapped.	Improve deburr instruction and verify effectiveness.
Capacity	Four machine days and separate inspection capacity were planned.	Replace assumptions with actual event and time data.
Broader conditions	Other machine, stock-lot variation and long tool life not demonstrated.	Keep restrictions; plan evidence before expansion.

The team releases L1 for shipment but does not remove 100% K1 monitoring from the next order. H-90-02 shows that the process still benefits from the launch response. The deburr issue also prevents a clean claim that the whole route is mature. The agreed next review will consider sustained evidence across further setups, resolved actions and the intended operating range; no arbitrary "three lots and done" rule is imposed.

Write the decision in plain language

WORKED WORDING

Release L1: 100 identified Rev B bodies under REL-90-02. Maintain CP-90-02 controls for the next order. No authorization for alternate machines, coating or unapproved tool substitutions. Manufacturing owns the deburr action; quality owns effectiveness review. Customer approval is required for any product-requirement change.

CLOSE ACTIONS WITH EVIDENCE

A shipment date does not close a production-introduction project. Transfer open actions to named owners and make restrictions visible to planning before the next purchase order is accepted.

27 / CHANGE MANAGEMENT

Classify changes by their impact

The word minor is not an engineering analysis.

For each proposed change identify affected product requirements, process steps, measurement methods, prior evidence and inventory. Decide what must be repeated and who must approve it. The table below is a review prompt, not a universal authorization rule; contracts may require notification or approval even when the technical impact appears small.

Proposed change	Potential impact	Proportionate review
New stock lot, same specification	Variation in stock condition or documentation.	Receipt and identity checks; assess need for targeted trial.
Replacement approved cutter	Offsets, runout and recovery of first-off condition.	Released replacement procedure and affected-feature checks.
Different holder / overhang	Stiffness, access, chatter or collision risk.	Setup review, verification and affected-feature trial.
New fixture or machine	Locating, motion, thermal behavior and datum transfer.	Updated baseline and representative route verification.
Added coating	Final size, masking, surface function and external process.	Design review, finish route and final-state evidence.
Drawing revision	Function and acceptance requirements.	Design authority plus impact review of WIP and released stock.

Record the effective serial or lot boundary and how old stock is handled: use as-is under the existing revision, rework under an approved route, return or scrap. Never infer interchangeability solely from the fact that both revisions fit one test assembly. Review documentation, labels and inspection programs as well as machining.

> **REVALIDATION IS NOT ALL-OR-NOTHING**
>
> Targeted evidence may be sufficient for a bounded change, while a broader change may invalidate most of the prior route evidence. Document the rationale. Do not impose full PPAP on every general CNC change or bypass it where the customer actually requires it.

Sources: [02] SAE International | [04] ISO

28 / REPEAT-ORDER READINESS

Restart a dormant or transferred job

A familiar part number can hide a changed manufacturing system.

Before restarting a job after a gap, compare the current state with the released pack: equipment, fixture condition, program, tools, operators, material, external suppliers, inspection method and customer revision. A backup file restores information; it does not verify the physical machine or fixture.

Restart check	Evidence to retain
Commercial and product baseline	New order reconciled to drawing revision, quantity, delivery and acceptance requirements.
Physical route	Machine and fixture identity, condition checks, setup instruction and available tools.
Program and coordinates	Released file verification, offset reset and approved dry-run / first-off process.
People and method	Qualified operators can execute the current instruction; temporary launch controls remain visible.
Inspection readiness	Equipment status, verified program, method revision and reference artifacts are available.
Old open items	Prior holds, rework causes, deviations and effectiveness actions reviewed before release.

If the original machine is unavailable, do not describe the replacement as equivalent merely because it has the same axis count or brand. Assess what changes in motion, fixturing, tool setup, thermal behavior, postprocessing and verification. Plan representative evidence on the receiving route and preserve a link to the original baseline.

Transfer useful knowledge, not just files

Include the failure history and the reason behind special instructions. For MB-90, the seating checks and 25.035 trigger must travel with the job. Removing them because the new supplier has no memory of PIL-01 discards the most valuable learning in the introduction package.

> **ASK FOR A DELTA STATEMENT**
>
> A concise list of what is unchanged, changed and unknown is more useful than an unsupported "same process" assurance. Review unknowns before the job is treated as a routine reorder.

Sources: [04] ISO | [09] Renishaw

29 / PACKAGING AND RECEIVING

Preserve conformity through delivery

A released part can still be damaged, mixed or contaminated after inspection.

Define packaging from the surfaces and risks that matter: contact damage, corrosion, residue, trapped moisture, sensitive edges, cleanliness and loss of identity. Protect critical surfaces without applying an unapproved oil, adhesive or material that creates a new downstream problem. Agree compatibility with the actual storage and transport conditions.

Delivery element	Case instruction / evidence
Part separation	No metal-to-metal contact on K1 or mating faces; protective material approved for the application.
Status and labels	Part number, revision, order, lot, quantity and release status reconcile with the packing list.
Mixed or split shipments	Separate containers and documents; no mixing of pilot-only pieces with L1.
Document pack	Required certificate, dimensional report, approved deviations and release reference accompany delivery.
Receiving check	Customer confirms count, identity, condition and agreed acceptance evidence.
Damage response	Photographs, container ID, affected quantities and preserved packaging support investigation.

Use a packaging trial or transport test where the consequence and route justify it. A photograph of a neatly packed box is not evidence that a delicate feature survives the expected journey. If an industry or customer test method is required, specify the actual method and criteria rather than inventing a generic "drop tested" claim.

Keep disposition control after shipment. If a material or process issue is found later, the lot map should identify the affected inventory and customer deliveries without automatically condemning every part ever made. Preserve enough records to justify the scope and comply with the retention terms agreed for the project.

DELIVERY IS A HANDOFF

Ask the customer to report assembly interference or repeated receiving damage against the part and lot IDs. Feed that evidence back to design, the risk register and the route. A production launch is incomplete if field feedback has no owner.

Sources: [04] ISO | [11] ISO

30 / BUYER-SUPPLIER AGREEMENT

Order the evidence you actually need

Make the pilot, production quantity and approval work visible in the commercial scope.

A quotation for pieces alone may not include fixture validation, a repeat pilot, extensive measurement, retained samples, external testing or a customer-specific submission. Identify these deliverables early. Agree who owns reusable tooling and programs, where they are stored, how long records are retained and what happens if the design changes before production.

Commercial question	What to state
Pilot quantity	Number of starts and tests, whether destructive, deliverable or pilot-only.
Failure and repeat	Who authorizes extra trials and how investigation time and scrap are handled.
Production commitment	Accepted delivery quantity, approved overrun rules and handling of shortages.
Evidence package	Reports, raw data where required, certificates, format and review time.
Change / deviation	Notification, approval authority, effective boundary and cost/schedule effects.
Retention / ownership	Tooling, records, samples and released-file access terms.

WORKED WORDING

Please quote a separate pilot and first order for MB-90 Rev B. The pilot is not deliverable production stock. Identify the proposed machine, fixture, route and measurement plan; include setup-recreation trials and actual results. Do not proceed to the first order until the agreed reviewer authorizes the bounded route. State exclusions, review lead time and the process for additional trials or changes.

Attach the controlled drawing and model rather than embedding sensitive technical data in a general inquiry field. Use the agreed secure transfer channel for proprietary information. A generic downloadable worksheet should organize a discussion, not encourage uncontrolled circulation of customer drawings.

PUT RESTRICTIONS ON THE ORDER

If only one route is approved, reflect that in planning and purchasing records. A lower-priced alternate route still needs the required technical review before it replaces the one that generated the evidence.

31 / PRACTICAL TROUBLESHOOTING

Five situations that need a decision

Use these prompts when a launch meeting sounds confident but the evidence is incomplete.

Situation	Better next decision
"All three prototypes fit."	Accept the observed assembly result within its scope. Request a production-route plan and evidence for normal setups, people and tool events.
"The Cpk is excellent."	Ask which data, revision, stability evidence, method and assumptions support it. Inspect ordered results before accepting the index as release evidence.
"We will inspect everything."	Confirm the method can detect the relevant failure and that capacity exists. Inspection does not substitute for functional validation or required process qualification.
"Only the supplier changed."	Review material or external-process equivalence, traceability and contract notification rules. Supplier identity can affect the route even if the drawing stays fixed.
"Ship now; the report will follow."	Determine whether the missing record is a contractual release condition. Obtain the authorized decision; do not silently change the agreed evidence sequence.

Escalate the uncertainty precisely

Instead of saying "quality is concerned", state: "The new fixture has not been evaluated after full removal and reinstallation; the previous failure occurred at that boundary. We need the defined setup-recreation evidence or a documented restriction on use." A specific evidence gap is easier to resolve than a general objection.

If a decision is deferred, name the owner, requested evidence and deadline. If the team accepts a residual risk within its authority, record the scope and conditions. An unsigned note from a meeting participant is not automatically the customer's approval to deviate from the drawing.

> **ASK WHAT WOULD CHANGE THE DECISION**
>
> A useful gate review has an answer: a missing test, closed action, demonstrated route, reconciled lot or explicit approval. More pages of the same evidence will not resolve a different unanswered question.

Sources: [05] NIST/SEMATECH | [11] ISO

32 / ACTION CHECKLIST

Your next-order readiness review

A compact review to complete before production is treated as routine.

Review area	Question to answer with a record
Product	Are function, final-state requirements, revision and document precedence resolved?
Process	Does the released route match the equipment, fixture, tools and people that will run the order?
Evidence	Are trial conditions, raw results, failures, changes and limitations visible?
Measurement	Is the method suitable, repeatable enough for the task and linked to the agreed decision rule?
Control	Are launch triggers, sampling frequencies, tool events and stop/restart authority executable?
Capacity	Are accepted output, losses, machine occupancy, labor, inspection and review time accounted for?
Release	Are physical quantity, product status, documents and approval scope reconciled?
Continuity	Are changes, restarts, retained knowledge and field feedback assigned to owners?

Use the next three worksheets as the front sheets of a project file. Worksheet A defines the pilot and its coverage. Worksheet B captures a hold, its affected population and the evidence for restart. Worksheet C records the first-lot gate and the restrictions passed to the next order. Attach detailed records instead of squeezing a technical report into the form fields.

A useful introduction package makes uncertainty visible and supports a bounded decision. It does not need to be large for its own sake. Remove duplicate paperwork, but keep the records that explain which route was tested, what went wrong, what changed and why the released parts can be accepted.

BRING A DEFINED PROBLEM TO VETCNC

Share the drawing and model revision, intended use, critical interfaces, prototype lessons, expected order quantities and required evidence. Ask for a project-specific route discussion. Scope, capability, testing, commercial terms and release responsibilities must be confirmed for the actual part.

APPENDIX A / REUSABLE WORKSHEET

Your pilot and coverage plan

Define the decision before collecting data. Attach the released baseline, detailed run matrix and acceptance plan.

Part / drawing / model / order

Pilot objective and intended release

Machine / fixture / NC / route IDs

Operators / stock / tool conditions

Critical features / final part state

Method / decision rule / evidence IDs

Run matrix / quantities / exclusions

Stop triggers / hold and restart owners

Approval reference, date, untested conditions and follow-up evidence

- [ ] The trial covers the intended route and records every produced or canceled piece.
- [ ] Acceptance criteria, stop rules and approval authority are agreed before the run.

Save and reopen in a form-capable PDF reader. Fields do not calculate, sign an approval or transmit data. Attach detailed records separately.

APPENDIX B / REUSABLE WORKSHEET

Your hold and restart record

Preserve the original result. Separate suspect scope, product disposition and permission to restart.

Event / date / part and route revision

Trigger / original result / method

Last known normal / suspect IDs

Locations / quantities / shipment status

Investigation / alternatives checked

Containment and authorized disposition

Correction / changed documents

Reverification / results / attachments

Restart authority, effective part boundary, restrictions and follow-up owner

- [ ] All affected inventory is accounted for; original findings remain in the record.
- [ ] Restart evidence and required approvals are complete before cutting resumes.

Save and reopen in a form-capable PDF reader. Fields do not calculate, sign an approval or transmit data. Attach detailed records separately.

APPENDIX C / REUSABLE WORKSHEET

Your first-lot release review

Authorize identified output on a defined route. Do not use this front sheet as a substitute for the evidence package.

Part / revision / lot / accepted order

Released route and evidence index

Starts / first-pass / rework / scrap

Final accepted / held / shipped balance

Material / measurement / certificates

Open actions / deviations / owners

Decision / authorized quantity / date

Next-order controls and review trigger

Named approvers, approval references, effective scope and excluded conditions

- [ ] Product quantity, identity, evidence and contractual release conditions reconcile.
- [ ] The next order inherits all applicable restrictions and unresolved actions.

Save and reopen in a form-capable PDF reader. Fields do not calculate, sign an approval or transmit data. Attach detailed records separately.

REFERENCE REGISTER / 1

Primary sources and their scope

Public sources checked 20 September 2026. Linked titles open the source; the case, calculations and diagrams are original.

[01] AIAG

APQP & Control Plan: manuals and public implementation overview

Public overview of APQP 3rd Edition and Control Plan 1st Edition. Automotive customer applicability must be agreed; these manuals are not universal requirements for every CNC order.

[02] SAE International

AS9145: Aerospace APQP and Production Part Approval Process

Public scope for the November 2016 aerospace standard. This guide does not reproduce its licensed requirements or constitute a compliant PPAP submission.

[03] SAE International

AS9102C: Aerospace First Article Inspection Requirements

Public scope and June 2023 revision record. Use the full contractually required standard for an AS9102 FAI; a generic dimensional report is not automatically equivalent.

[04] ISO

ISO 10007:2017 - Guidelines for configuration management

Public catalogue scope; confirmed in 2023, with revision work listed. Supports configuration-management context, not a claim that the example register satisfies every clause.

[05] NIST/SEMATECH

Engineering Statistics Handbook: What is process capability?

Capability compares process behavior with specification limits. Stability, distribution, sampling and uncertainty matter. This guide deliberately does not turn a small pilot into a capability certificate.

[06] NIST/SEMATECH

Engineering Statistics Handbook: Confidence intervals for proportions

Public treatment of binomial confidence intervals. The zero-failure, one-sided calculations on page 17 are original derivations under explicitly stated assumptions, not a prescribed acceptance plan.

Catalogue records establish public scope and edition context, not access to every licensed clause. Apply the full agreed standards and customer requirements. The original case is not a substitute for formal product validation or an industry-specific approval package.

REFERENCE REGISTER / 2

Primary sources and their scope

Public sources checked 20 September 2026. Linked titles open the source; the case, calculations and diagrams are original.

[07] NIST/SEMATECH

Engineering Statistics Handbook: Selecting an experimental design

Experimental design depends on objectives, factors and resources. The case pilot is operational coverage, not a randomized factorial experiment or a causal statistical study.

[08] NIST

Metrological Traceability: Frequently Asked Questions and NIST Policy

NIST TN 2156 / policy context. Traceability belongs to measurement results and involves calibration chains and uncertainty; a calibration label alone does not establish fitness for the task.

[09] Renishaw

Process foundation

Manufacturer guidance on machine condition, inputs, environment and process design. It does not establish Vetcnc equipment, process capability, tool life or validation services.

[10] ASQ

Failure Mode and Effects Analysis: overview and method

Public explanation of proactive failure analysis. The compact risk-action table here is an original planning aid, not a complete customer-specific PFMEA or a mandated scoring system.

[11] ISO

ISO 10005:2018 - Guidelines for quality plans

Public scope for establishing, reviewing, accepting, applying and revising quality plans. It is guidance rather than a requirements standard; project authority remains with the contracting parties.

[12] NIST/SEMATECH

Engineering Statistics Handbook: What to do if the process is out of control?

Public discussion of assignable causes and an out-of-control action plan. The case uses explicit launch triggers, not statistically estimated control limits.

Sources support the principles identified in the guide; they do not endorse Vetcnc or validate the fictional case. Project-specific capability, tests, capacity and commercial deliverables require confirmation. No certification or independent professional approval is implied.

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CNC MANUFACTURING

FROM A GOOD SAMPLE TO A CONTROLLED ORDER

Make the next order a defined process.

Bring the drawing, prototype lessons and expected quantities. Start with the requirements and evidence your project actually needs.

01 **DEFINE**

The part revision, intended function and acceptance requirements.

02 **PLAN**

The production route, pilot coverage and evidence handoff.

03 **REVIEW**

The results, open risks and authorization for the next step.

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