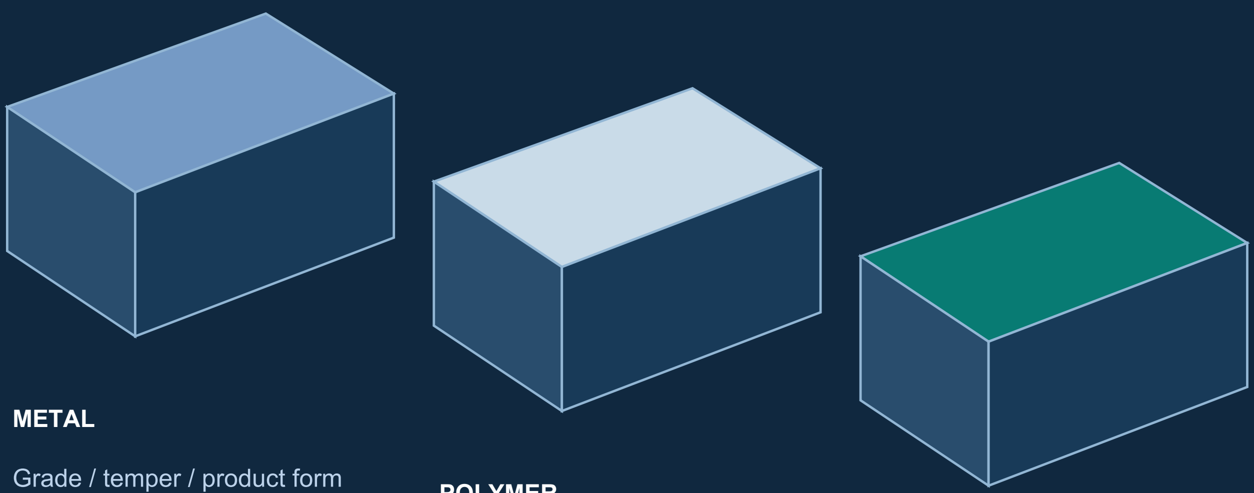
vetcnc
CNC MANUFACTURING

ENGINEERING RESOURCES / 03

CNC Materials & Surface Finishes

A Practical Selection Guide

Choose for function. Specify the final condition.
Validate what the datasheet cannot tell you.



METAL

Grade / temper / product form

POLYMER

Grade / state / time

SURFACE

Process / zone / acceptance

V1.0 / SEPTEMBER 2026

READER MAP

A selection guide you can use on a real RFQ

Move from an application to a defensible shortlist, a defined surface condition and a validation plan.

What this guide does - and does not - provide

You will find three original teaching cases, selected manufacturer data, reproducible calculations and worked specification examples. The aim is to help engineering buyers ask better questions and recognize when a material name or a finish label is insufficient. This is resource 03 in the vetcnc series; it complements the design and RFQ guides rather than repeating their blank forms.

The cases are not customer projects, production results or vetcnc capability claims. Published values are identified by source and product context; assumed inputs are labelled. Final design approval, safety factors, service-life prediction and regulated-use qualification remain with the responsible project team.

HOW TO READ THE NUMBERS

Unless stated otherwise, dimensions are mm. A value shown as typical is a screening input, not a procurement minimum. The single worksheet is on page 32; the main content is worked guidance.

01 / A PRACTICAL SELECTION METHOD

Start with the failure you cannot accept

The best material is the one that satisfies the actual constraints, not the one with the highest number in a catalogue.

FUNCTION →	ENVIRONMENT →	MATERIAL →	SURFACE →	EVIDENCE
What must work?	What attacks it?	Grade + state	Zone + process	Test + release

Application statement	Convert it into a reviewable requirement
"The housing must be light."	State the mass allowance, net geometry, what hardware is included and whether wall thickness may change.
"The bracket must not bend."	Identify load, lever arm, mounting stiffness and permitted deflection. Yield strength alone does not answer this.
"It must resist cleaning."	List the cleaner, concentration, temperature, contact time, rinse and trapped-liquid conditions.
"The surface should be black."	Identify cosmetic zones, reference appearance, protected interfaces and the process compatibility needed.

Separate mandatory gates from preferences. A material with an unverified temperature limit or an unacceptable electrical interface is not rescued by a low quoted price. Once the gates are met, compare manufacturability, availability, finishing, inspection and repeat supply on the same scope.

Use three statuses: supported, contradicted and unknown. Unknown is not a weak pass. Give every critical unknown an owner and a test or evidence request. This prevents a visually attractive scorecard from hiding the one missing fact that controls the whole application.

A USEFUL FIRST DELIVERABLE

Write a half-page duty statement before asking for an alloy recommendation. Include what the part touches, what loads it carries, what it is exposed to and what would count as failure.

02 / EVIDENCE LITERACY

Read the property, not just the number

A comparison becomes misleading when the units match but the conditions behind the values do not.

Data label	Correct interpretation	Common misuse
Typical value	Representative published information under stated conditions.	Using it as a guaranteed minimum for every delivered lot.
Minimum requirement	A lower bound within a particular product specification and scope.	Applying a plate requirement to bar or to a different thickness.
Yield strength	A defined onset of non-proportional or permanent deformation in a test.	Treating it as elastic stiffness or fatigue life.
Elastic modulus E	The elastic stress/strain slope in the stated test regime.	Assuming a stronger temper proportionally reduces deflection.
Hardness	A result on a named scale and test method.	Comparing HB, HRC and Shore D as if they were the same unit.
Polymer service temperature	A manufacturer rating with its own intended interpretation.	Assuming a tight dimension survives that temperature under load.

Record the source, grade, temper or conditioning state, product form, test temperature, direction, test method and whether the number is typical or guaranteed. If one item is absent, keep the comparison qualified. A familiar alloy designation is not enough to reconstruct a missing test condition.

A worked reading check

Kaiser publishes a typical 6061-T6/T651 yield value of 276 MPa for its referenced product sheet [01]. That does not establish a 276 MPa minimum on your purchase order. A project must select the appropriate current product specification and thickness/condition requirements, then obtain the relevant evidence for the actual stock.

> **DO NOT MIX PRODUCT FAMILIES SILENTLY**
>
> The 6061 and 7075 values later used for screening come from different stated manufacturer product sheets. They illustrate strength versus stiffness; they do not qualify interchangeable production stock.

Sources: [01] Kaiser Aluminum | [02] Kaiser Aluminum | [11] Ensinger

03 / METAL SCREENING MAP

A metal shortlist organized by purpose

Start with a material family that addresses the function, then narrow to grade, state and product form.

Candidate	Why it enters the shortlist	What can disqualify it
6061, specified temper	General machined aluminum candidate where mass, fabrication and surface treatment matter.	Unverified stress, temperature, wear or interface performance.
7075, specified temper	Strength-led aluminum candidate; compare the actual temper and corrosion duty.	Assuming greater strength fixes a stiffness problem or that every finish looks like 6061.
304L / 316L	Austenitic stainless candidates, selected against the environment and fabrication route.	An undefined cleaner, crevice, chloride exposure or mechanical requirement.
17-4 PH / final condition	A precipitation-hardening stainless route when condition-dependent mechanical properties matter.	No final aging condition or dimensional plan for later heat treatment.
Ti-6Al-4V / grade and state	A titanium candidate when its combination of mass and application-specific properties is justified.	Treating Grade 5 and ELI variants as automatic substitutes; unsupported process economics.
C11000 / C36000	Copper for conductivity-led questions; free-cutting brass for a different set of machining needs.	Assuming brass retains copper conductivity or that leaded brass meets every end-use restriction.

This is a shortlist, not a ranking from best to worst. A supplier may be able to machine a material that is unsuitable for the assembly. Conversely, a technically suitable alloy may require a stock form, treatment or inspection route that changes price and schedule.

DEFINE THE PURCHASE, NOT ONLY THE CHEMISTRY

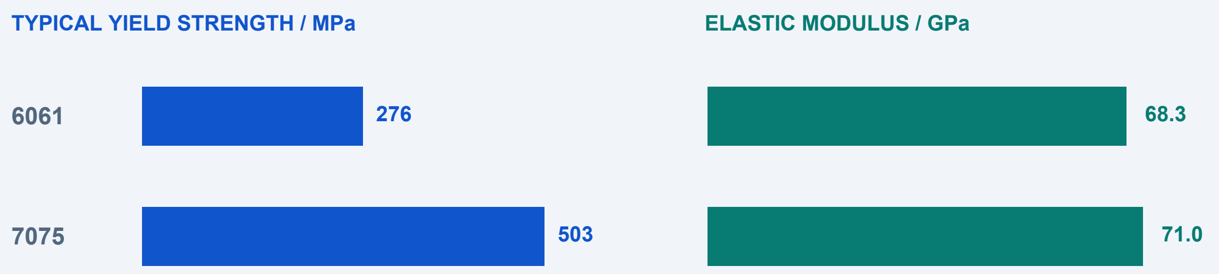
Name the alloy/grade, final condition, stock/product specification and necessary evidence. Allow alternatives only as separately identified proposals with their technical consequences shown.

Sources: [01] Kaiser Aluminum | [02] Kaiser Aluminum | [03] Outokumpu | [04] Outokumpu | [05] Carpenter Technology | [06] TIMET | [07] Copper Development Association | [08] Copper Development Association

04 / ALUMINUM TRADEOFFS

6061 and 7075: stronger is not much stiffer

Selected published typical values make one useful distinction visible; they are not a design-property specification.



Selected published values, not certified design allowables; see source/product notes below.

The selected sheets give 276 MPa typical yield and 68.3 GPa modulus for 6061-T6/T651 [01], versus 503 MPa and 71.0 GPa for 7075-T6/T651 rod/bar [02]. The yield values differ substantially; the moduli are close. A material change can therefore improve a strength margin without solving a deflection complaint.

Decision	What to do with the comparison
Part bends but stays elastic	Calculate the elastic response and consider section shape, thickness, span and mounting before buying a stronger alloy.
Part approaches permanent deformation	Use appropriate minimum/allowable properties for the actual form and condition, then check stress concentrations and loading.
Sustained load in a corrosive environment	Review temper and corrosion behavior together; do not pick a temper from strength alone.
Matched cosmetic appearance	Approve representative samples from the selected alloy, stock and preparation route. Do not use a different alloy as the appearance master.

A T6/T651 shorthand is not permission to substitute any available stock. State the required condition in the actual purchase description. Ask how stock history and machining sequence affect distortion if a large pocket or an asymmetric section removes much of the blank.

> **KEEP THE EXAMPLE IN ITS LANE**
>
> Page 14 calculates a beam response with these published E values. It does not compare certified strength allowables across different product forms or approve either alloy for a safety-critical part.

Sources: [01] Kaiser Aluminum | [02] Kaiser Aluminum

05 / STAINLESS SELECTION

304L and 316L: ask what the liquid is

A stainless designation narrows the discussion; it does not describe the environment.

Question	Useful answer	Selection consequence
What is the exposure?	Named fluid or cleaner with concentration, temperature and duration.	A generic "chemical resistant" claim is not enough.
Where can liquid remain?	Seal grooves, fastener interfaces, blind cavities and deposits identified.	Evaluate localized attack and drainage, not only open-surface appearance.
Will it be welded?	Joining route, final condition and surface-restoration plan.	Review the completed fabrication, not merely the incoming sheet.
What is the mechanical duty?	Load, permitted movement and required material condition.	A corrosion-led candidate still needs mechanical validation.
What evidence is needed?	Material identity, surface treatment and project-specific test criteria.	Do not interpret one certificate as a service-life guarantee.

Outokumpu places 304/304L in its Core family and molybdenum-alloyed 316L variants in its Supra family [03,04]. That is a useful starting distinction. Its corrosion guidance makes the actual environment central to suitability [18]; increasing an alloy label is not a substitute for knowing what the part sees.

A better question than "Which stainless is best?"

> **WORKED WORDING**
>
> "This block is cleaned with the specified solution at the stated concentration and temperature, then rinsed and drained. Review the groove and bolted interface for retained liquid. Compare candidate grades and the completed surface route against this exposure; identify the evidence still needed."

For a real wet-service part, the cleaning process may change during its life. Make the approved chemical envelope visible to operations and maintenance. A later cleaner substitution is an engineering change, even if no drawing dimension changes.

Sources: [03] Outokumpu | [04] Outokumpu | [18] Outokumpu

06 / HEAT TREATMENT AND SEQUENCE

17-4 PH: the condition is part of the material

An alloy name alone leaves the final mechanical state and dimensional sequence unresolved.

STOCK	MACHINING	AGE / FINISH
Identify condition	Plan remaining stock	Verify final geometry

Carpenter describes Custom 630 / 17-4 as a precipitation-hardening stainless and distinguishes aging conditions with different property outcomes [05]. Condition A is not a substitute for a specified aged condition. A drawing that says only "17-4" leaves a consequential decision open.

Decision record	What belongs in it
Starting stock	Applicable material specification, product form, supplied condition and lot evidence.
Final material state	The exact approved condition; do not let the supplier choose it from a hardness preference alone.
Process route	Whether machining precedes or follows the final treatment, which surfaces are finished afterward and what must be rechecked.
Acceptance	Required property evidence, treatment traceability and final dimensional verification.

A dimensional thought experiment

The manufacturer describes contraction during aging [05]. To see why sequence matters, assume a particular trial route produces 0.05% uniform linear contraction. On 100 mm that is 100 x 0.0005 = 0.050 mm. A pre-treatment dimension cannot simply be treated as the final result. This assumed uniform change is a screening example, not a machining allowance for 17-4.

> **APPROVE THE COMPLETE ROUTE**
>
> Do not convert this page into a furnace recipe. Confirm the controlled treatment, geometry response and final inspection with the responsible materials/process personnel and the supplier.

Sources: [05] Carpenter Technology

07 / AVOID EXPENSIVE SUBSTITUTIONS

Titanium, copper and brass solve different problems

An attractive material reputation can conceal a mismatch with the actual function.

Material family	Useful source distinction	Practical review
Ti-6Al-4V	TIMET distinguishes standard 6-4, ELI and ruthenium-containing variants. Its reference density is 4.42 g/cm3 [06].	State the grade and product specification. Ask what application need justifies this route and what verification is required.
C11000 ETP copper	CDA identifies a high-conductivity copper; conductivity is tied to stated material context [07].	Define current/heat-transfer duty, joints, delivered temper and any coating on contact surfaces.
C36000 free-cutting brass	CDA classifies it as a leaded brass, with 2.5-3.0% Pb in its listed composition [08].	Review end-use substance requirements separately. Do not assume machinability makes it a drop-in copper replacement.

A conductivity comparison with a narrow meaning

The CDA records list 101% IACS for C11000 and 26% IACS for C36000 under their stated reference conditions [07,08]. For equal geometry at that reference condition, electrical resistance is inversely proportional to conductivity: 101 / 26 is about 3.88. This screens out the idea that the brass offers the same bulk electrical behavior.

It does not calculate an assembly temperature, allowable current or connection reliability. Those depend on geometry, heat rejection, duty cycle and contact resistance. Do not select an electrical part by bulk material conductivity without addressing the joints and their final surfaces.

> **ASK FOR A JUSTIFIED ALTERNATIVE**
>
> A substitution proposal should identify the property that changes, the affected function, any drawing or process changes and the validation needed. A similar color or trade name is not evidence of equivalence.

Sources: [06] TIMET | [07] Copper Development Association | [08] Copper Development Association

08 / THREE USEFUL REFERENCE CANDIDATES

A polymer shortlist needs a named grade

The following are specific unfilled stock-shape examples, not universal values for all plastics in each family.

Reference product	Density g/cm3	Tensile E MPa	CLTE 10^-6/K
POM-C / TECAFORM AH natural [09]	1.41	2,800	130
PA 6 / TECAMID 6 natural [10]	1.14	3,300	120
PEEK / TECAPEEK natural [11]	1.31	4,200	50

E is the published tensile-test modulus at 1 mm/min to DIN EN ISO 527-2. CLTE is the published longitudinal coefficient over 23-60 C to DIN EN ISO 11359-1;2. Values are reference data, not guaranteed part limits. A glass-filled, carbon-filled, lubricated, colored or conductive variant needs its own record.

Candidate question	What to verify next
POM-C for a room-temperature locator	Actual cleaner compatibility, sustained load and the dimensional effect of temperature.
PA 6 for a mechanically loaded component	Moisture conditioning, the environment at inspection and the resulting dimensions and properties.
PEEK for a hotter or more demanding duty	Grade-specific mechanical performance at temperature and time, economics and whether the feature actually needs this material.

A test-method name helps you compare like with like; it does not make every test specimen equivalent to a machined component. Orientation, residual stress, support, conditioning and geometry still matter. Do not replace a flexural or compressive analysis with the tensile E column solely because it is convenient.

DO NOT CONVERT ABSORPTION INTO GROWTH

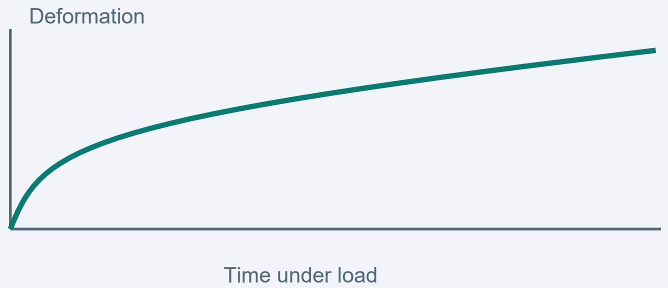
A water-uptake percentage by mass is not the same quantity as linear dimensional expansion. Obtain dimensional data or test the actual grade and conditioning route rather than multiplying a length by that percentage.

Sources: [09] Ensinger | [10] Ensinger | [11] Ensinger | [12] Ensinger

09 / POLYMER DIMENSIONAL BEHAVIOR

Temperature and time can change the answer

A successful immediate measurement is not proof of stable geometry through storage, load and service.



SCHEMATIC ONLY

An immediate elastic check does not predict long-term creep or retained clamp force.

Separate four mechanisms in the review: immediate elastic deformation, time-dependent creep under load, thermal movement and dimensional change associated with moisture or released residual stress. They are not four names for the same correction. A part that passes an unloaded room-temperature check may still move during its actual duty.

Observation	Next discriminating check
Dimension changes after warm storage	Compare stabilized measurements before and after a defined thermal cycle; separate reversible expansion from permanent change.
A clamp loses force over time	Evaluate the actual sustained load, contact area and duration; an initial torque reading alone is not a retained-force test.
Dry and wet measurements differ	Identify grade and moisture state; use a controlled conditioning comparison rather than an arbitrary offset.
Filled stock behaves differently by direction	Retain the stock orientation and evaluate the property direction relevant to the feature.

Ensinger identifies moisture, thermal history, stress relaxation and processing/orientation effects as relevant mechanisms [12]. The useful action is to define the final inspection state and the actual service state, then show what evidence connects them. A generic material datasheet cannot supply that connection by itself.

TURN THE CONCERN INTO A TEST

Specify the initial condition, exposure, load, duration, measurement time and permitted change. Use an unloaded control where helpful. A test that changes all those variables at once is difficult to interpret.

Sources: [12] Ensinger

10 / COMPATIBILITY AND CORROSION

Define the environment as a set of exposures

A service description should be specific enough that a materials specialist can evaluate the same duty you intend.

Exposure variable	Record this	Why it matters to the decision
Chemical contact	Product identity, composition information, concentration and any contamination.	A trade name or a pH value alone may omit important chemistry.
Temperature and duration	Normal range, peaks, dwell time and cycling.	A brief rinse and a long hot soak are different duties.
Geometry and assembly	Crevices, deposits, seals, drainage and dissimilar-metal interfaces.	A clean exposed coupon may not represent a trapped-liquid joint.
Mechanical state	Stress, sliding contact, impact, sustained load or cycling.	A compatibility statement without loading context can miss the controlling failure.
Maintenance and life	Cleaning sequence, inspection access, expected cycles and replacement policy.	The approved exposure must survive ordinary maintenance changes.

Outokumpu describes corrosion resistance as a relationship between material and environment, including localized and galvanic mechanisms [18]. When dissimilar metals are electrically connected in an electrolyte, assess the joint rather than assigning each metal an independent pass. Isolation, drainage and protective treatments require validation as a system.

A completed exposure statement

> **WORKED WORDING**
>
> "The WB-40 teaching block sees Cleaner X at 2% by mass and 50 C for 20 minutes per daily cycle, followed by the defined rinse and drying step. Cleaner composition has not yet been supplied. The gasket groove may retain liquid. Material selection remains on hold until the chemical and joint review is complete."

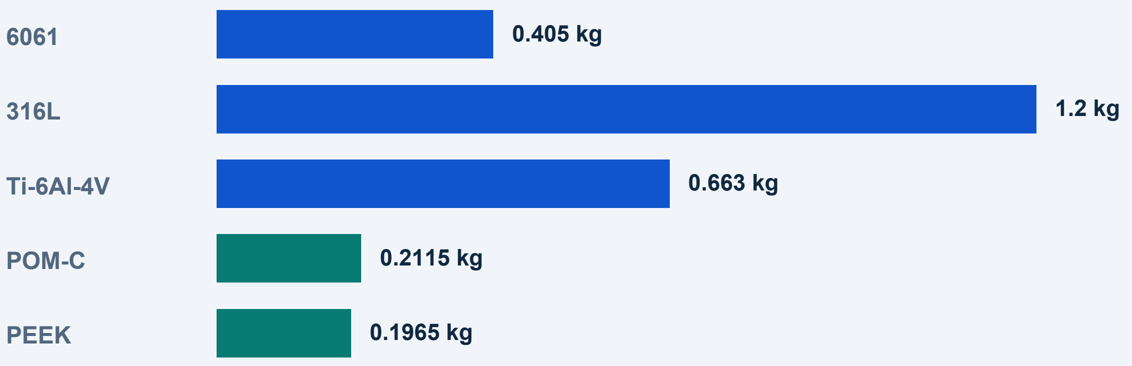
> **AVOID INVENTED COMPATIBILITY RATINGS**
>
> Cleaner X is deliberately unspecified. This guide cannot conclude that 316L, aluminum or a polymer is compatible with it. Request the actual chemistry and a justified test envelope.

Sources: [18] Outokumpu

11 / WORKED EQUAL-VOLUME SCREEN

Calculate mass before making a material promise

Density is an easy first calculation, provided the volume and the scope of the mass limit are clear.



Same net volume: 150 cm3. Not equal performance.

Assume an original housing concept has 150,000 mm3 net solid volume. Since 1 cm3 = 1,000 mm3, the net volume is 150 cm3. Mass in kg = volume in cm3 x density in g/cm3 / 1,000. This calculation is for the machined body only; screws, inserts, finishes and attached equipment are excluded.

Reference material / source	Density g/cm3	Calculated body mass
6061 [01]	2.70	0.405 kg
316L/4404 [04]	8.00	1.200 kg
Ti-6Al-4V reference [06]	4.42	0.663 kg
TECAFORM AH natural [09]	1.41	0.2115 kg
TECAPEEK natural [11]	1.31	0.1965 kg

With a fictional 0.50 kg body-only limit, the unchanged 6061 geometry passes this mass screen; the unchanged 316L and titanium versions do not. That conclusion says nothing about stiffness, strength, thermal behavior or manufacturing suitability. The two polymers are lighter at equal volume, but that does not make them equivalent housings.

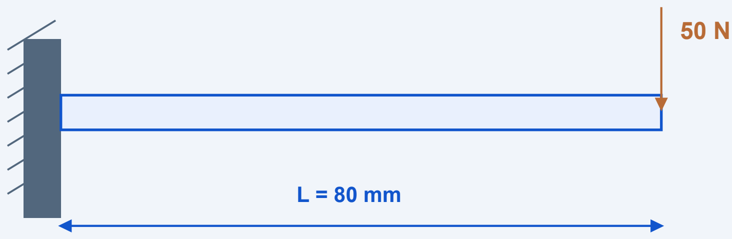
> **THE GEOMETRY CAN CHANGE THE RANKING**
>
> If a candidate needs thicker walls, recalculate its actual net volume. Compare complete candidate designs when the geometry is allowed to vary; equal-volume mass is only the first filter.

Sources: [01] Kaiser Aluminum | [04] Outokumpu | [06] TIMET | [09] Ensinger | [11] Ensinger

12 / WORKED ELASTIC-DEFLECTION SCREEN

A thickness change can beat an alloy change

An idealized beam makes the difference between stiffness and strength concrete.



RECTANGULAR SECTION
Width b = 20 mm
Thickness h = 6 mm
I = bh^3 / 12 = 360 mm4

Ideal fixed end; tip load; small-deflection elastic model.

Use the small-deflection cantilever relation delta = F L^3 / (3 E I) [21]. For a rectangular section bending through thickness h, I = b h^3 / 12. Assume F = 50 N, L = 80 mm, b = 20 mm and h = 6 mm, so I = 360 mm4. Use E in N/mm2: 68.3 GPa becomes 68,300 N/mm2.

Screening option	Inputs changed	Calculated tip deflection
6061 / baseline	E = 68,300; h = 6	0.347 mm
7075 / same section	E = 71,000; h = 6	0.334 mm
6061 / thicker section	E = 68,300; h = 8; I = 853.33	0.146 mm

Changing the published E input reduces the calculated deflection by about 3.8%. Increasing thickness from 6 to 8 reduces it by about 57.8%, while increasing the mass of this constant-width beam by 33.3%. That is a real tradeoff to discuss if extra thickness fits the assembly.

The result is not a strength check or a model of the complete housing. It assumes an ideal fixed end, a uniform prismatic section, linear elastic behavior and a transverse tip load. Real joints, holes, contact compliance, shear deformation, fatigue and local stresses need their own evaluation.

USE THE CALCULATION TO CHANGE THE CONVERSATION

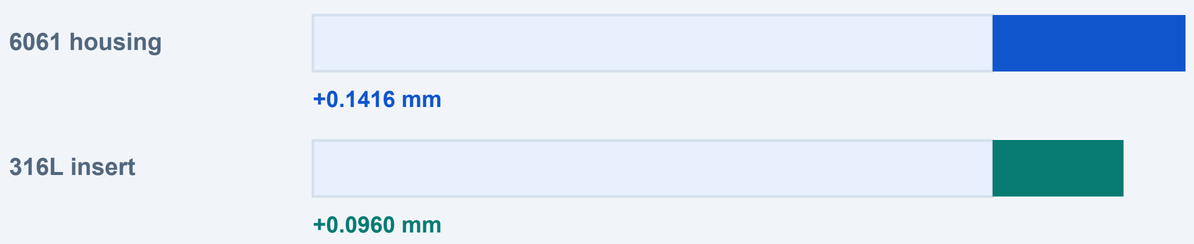
If the issue is elastic movement, review span, section and mounting. If the issue is yielding or fatigue, establish the appropriate material allowables and load history instead.

Sources: [01] Kaiser Aluminum | [02] Kaiser Aluminum | [21] MIT OpenCourseWare

13 / DIFFERENTIAL THERMAL EXPANSION

A fit can change after both parts get warm

Two parts that fit at inspection temperature do not necessarily move together in service.



150 mm at 20 C; both rise uniformly to 60 C. Growth exaggerated.

Assume a 6061 housing and a 316L insert each have a 150 mm locating span at 20 C. Both rise uniformly to 60 C, so delta T = 40 K. Use the published mean coefficients over 20-100 C: 23.6 x 10^-6 /K for 6061 [01] and 16.0 x 10^-6 /K for 316L/4404 [04]. Treat them as constant for this first-order screen.

Calculation	Result
6061 free growth: 150 x 23.6 x 10^-6 x 40	0.1416 mm
316L free growth: 150 x 16.0 x 10^-6 x 40	0.0960 mm
Difference in unconstrained growth	0.0456 mm

Suppose one end is located and the other end has a centered slot offering 0.10 mm total axial travel at 20 C. Only 0.05 mm is available in the warm-growth direction. Subtracting 0.0456 leaves just 0.0044 mm before allowing for manufacturing limits, positioning, temperature uncertainty or unequal heating. Nominal clearance alone is not a robust justification.

If both ends are rigidly constrained, the same free-growth difference does not appear simply as movement: the restraint changes the load and stress problem. Do not turn the above subtraction into a thermal-stress result. Define the actual constraints and temperature distribution.

KEEP INSPECTION AND SERVICE STATES SEPARATE

State the reference condition for measured dimensions, then evaluate the operating condition. NIST discusses the 20 C dimensional reference [22]; this screen is not a complete uncertainty analysis.

Sources: [01] Kaiser Aluminum | [04] Outokumpu | [22] NIST

14 / COMPLETED SELECTION RECORD

Case A: select a route for a small housing

IH-150 is an original instrument-housing concept used to connect mass, interfaces and finishing decisions.

Teaching requirement	Decision or consequence
150 cm3 net body; body mass <= 0.50 kg	6061 screen: 0.405 kg. The unchanged 316L and Ti-6Al-4V geometries exceed this mass allowance.
Indoor instrument; defined 20-60 C duty	Check thermal movement with the attached steel interface, not only room-temperature fit.
Thermal seating face and electrical bonding pad	Assign separate finish zones; cosmetic exterior treatment must not silently cover these interfaces.
Black exterior appearance	Evaluate an aluminum anodizing route with representative preparation/color samples. Appearance is not the only acceptance criterion.
Local stiffness requirement still to be proved	Use an actual housing/assembly model or test. The beam calculation is not approval of this geometry.
Provisional material	6061-T651 plate to the approved product specification; no unreviewed substitution. Confirm thickness, availability and evidence before release.

Why this is a defensible shortlist decision

The mass calculation gives a clear reason to carry the aluminum candidate forward. There is no stated strength-driven need that justifies automatically switching to 7075, and the E comparison shows why it is not a stiffness cure. The choice remains conditional on the actual mechanical, thermal and finish-interface checks.

The next step is specific: release a prototype definition with finish zones, test the mechanical interfaces and thermal behavior, then approve the production requirements from the evidence. A provisional selection is useful when its open gates are explicit; it is dangerous when an assumed pass is hidden.

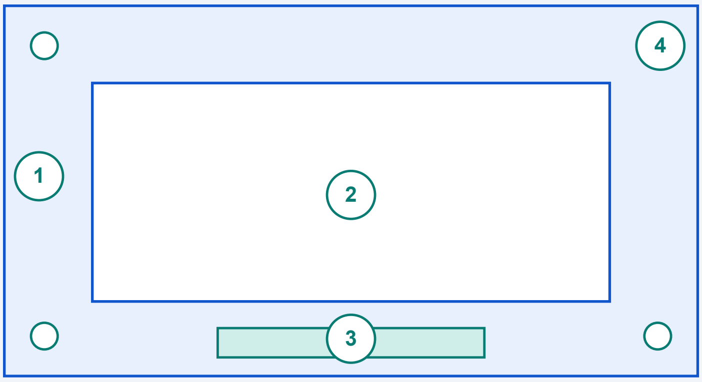
CHANGE THAT REOPENS THE SELECTION

Outdoor exposure, a new cleaner, a higher temperature, a different bonding requirement or thinner walls can invalidate this record. Re-evaluate the affected gates instead of copying the old material line forward.

15 / THE HOUSING FINISH MAP

Specify the surface by functional zone

One instruction saying "black anodize all over" can contradict the functions of several different surfaces.



1 / Exterior
Selected cosmetic finish

2 / Thermal seat
Protect interface requirement

3 / Bonding pad
Define electrical condition

4 / Threads
Final functional acceptance

HOUSING CONCEPT / NOT A PRODUCTION DRAWING

Zone	Teaching instruction	Acceptance question
1 / exterior	Selected anodizing route, preparation and approved appearance reference.	Does the visible finish match the defined sample and defect criteria?
2 / thermal seat	Protect the specified final contact condition; define masking or approved alternative.	Do flatness, texture and the assembled thermal interface meet the requirement?
3 / bonding pad	Drawing-defined area and approved conductive surface route.	Is the actual assembled contact resistance within its defined limit?
4 / threaded features	Define treatment extent and final thread requirement; agree masking where appropriate.	Are the delivered threads functional after all operations?

The sketch is a concept map, not a released drawing. A production mask boundary needs a location, permitted transition, protected features and inspection criteria. Also identify acceptable racking/contact locations; do not leave a visible witness mark or an electrically isolated pad to chance.

> **DO NOT MAKE A MASKING INSTRUCTION DO TWO JOBS**
>
> Masking controls exposure to a process. It does not itself establish corrosion protection, cleanliness, bonding performance or thermal-contact quality on the uncovered surface.

Sources: [13] NASA / JSC | [14] NASA / JSC

16 / ALUMINUM OXIDE FINISH

Anodizing: define more than a color

Anodizing changes the surface; selecting it requires both a finish specification and an interface review.

Decision	What the buyer/designer needs to define
Purpose	Cosmetic appearance, wear-related duty, corrosion-related duty or another function. One finish choice may not optimize every purpose.
Process identity	Agreed standard and revision, process type, class/color as applicable, thickness and permitted variation.
Surface preparation	Machining texture, blasting or other approved preparation and where it is allowed.
Protected areas	Threads, fit diameters, electrical pads, thermal seats, seals and designated contacts.
Delivered condition	Sealing/post-treatment where required, final dimensions and appearance evidence.
Verification	Which thickness locations, functional features and appearance zones are checked; report or certificate scope.

NASA's public anodizing document discusses process designation, preparation, thickness and geometric effects [13]. It is useful technical context, but its default values are not adopted here. Its public Rev. D copy is older than the revision listed in the current PRC index [20]. Use the controlled specification actually agreed for the job.

Two decisions that should remain separate

A color approval addresses a visual result. A dimensional approval addresses the final geometry. Passing one does not prove the other. Likewise, an exterior wear-related treatment does not establish the load-bearing strength of the base metal or qualify an electrical insulation function.

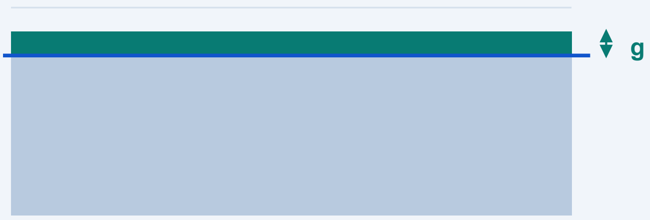
> **USEFUL ALTERNATIVE TO "STANDARD BLACK"**
>
> Ask for a proposal against the duty and zones, including thickness range, preparation, masking and representative sample. Approve the complete route, then place that route under revision control.

Sources: [13] NASA / JSC | [20] NASA / JSC

17 / WORKED DIMENSIONAL ALLOWANCE

Budget finish growth into a tight bore

This separate bore example shows the calculation once the process has supplied a credible net-growth range.



Original surface

Net movement is the input.

Shaft: D final = D pre + 2g
Bore: D final = D pre - 2g

Do not substitute oxide thickness for g without a validated process.

Assume the final bore must be 20.000-20.018 mm. For this teaching example only, a validated route is assumed to give net inward growth g = 0.005-0.010 mm per side, including the net effect of preparation and treatment. This is not a claimed anodizing growth range. Let D final = D pre - 2g.

Worst-case condition	Required pre-treatment bore
Smallest final bore: D pre,min - 2 x 0.010 >= 20.000	D pre,min >= 20.020
Largest final bore: D pre,max - 2 x 0.005 <= 20.018	D pre,max <= 20.028
Resulting pre-treatment window	20.020-20.028, or 20.024 +/- 0.004

Check the extremes: 20.020 - 0.020 = 20.000; 20.028 - 0.010 = 20.018. The process range has consumed 0.010 mm of the 0.018 mm final diameter window, leaving 0.008 mm for the pre-treatment diameter range. This leaves no extra allowance for an unmodelled shift or an inspection guard band.

If the shop cannot reliably hold that window, do not instruct it to "aim for the middle." Consider an approved masking route, a revised fit, a more tightly controlled treatment or qualified post-treatment finishing. Each alternative changes a surface or process requirement and needs review.

> **DO NOT HALVE A COATING SPECIFICATION BLINDLY**
>
> Oxide thickness and net surface movement are different quantities. Validate the actual process, feature and measurement method before using a growth model; the above numbers are assumed inputs.

Sources: [13] NASA / JSC

18 / CONVERSION COATING AND BONDING

Conductive contacts need their own finish decision

A finish that looks satisfactory can still be wrong for an electrical interface.

Appearance approval and electrical contact verification are separate acceptance tasks.

NASA's older public reference distinguishes corrosion-protection and lower-electrical-resistance classes [14]. A process class does not establish assembled-joint resistance. Confirm the controlled requirements and test the intended joint.

Define	Verify
Exact pad boundary and adjoining finish	The intended contact area is not covered by an unintended insulating treatment or contaminated by masking residue.
Approved coating system and sequence	The selected route is compatible with the substrate, adjacent operations and service environment.
Assembly condition	Counterpart, contact area, fastener/load condition and any approved interface material.
Electrical acceptance	Measured characteristic, method, applied conditions and limit established by the electrical design authority.
After exposure	Required retained performance after the actual temperature, humidity, vibration or other relevant duty.

For IH-150, keep the exterior and the bonding pad as separate zones in the release. Do not rely on someone scraping a coated surface during assembly. If abrasion or an exposed patch is part of the intended design, define its boundaries, debris control and protection requirements explicitly.

IMPORTANT SEPARATION

A contact-resistance result is not a product electrical-safety qualification. Obtain the application-specific electrical requirements; this guide does not establish safety compliance.

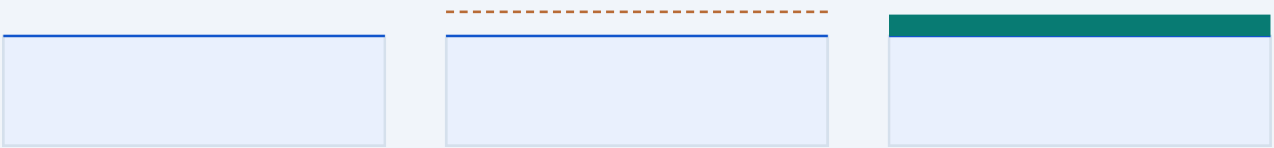
Sources: [14] NASA / JSC | [20] NASA / JSC

19 / STAINLESS SURFACE ROUTES

Passivation is not the same as polishing

Specify the outcome and process without asking a surface treatment to repair the wrong base material.

PASSIVATION | **ELECTROPOLISH** | **Ni-P PLATING**



clean / passive surface | controlled removal | added metallic deposit

Route	Primary distinction	What to state
Chemical passivation	A stainless surface treatment; not a decorative plated layer or a geometric leveling operation.	Applicable A967/A967M or other agreed specification, grade-appropriate route and verification.
Electropolishing	Electrochemical material removal and surface treatment, not simply another name for chemical passivation.	Applicable process, protected features, removal allowance and final geometry/texture requirements.
Mechanical polishing / blasting	A surface-preparation or finishing operation with its own contact/media effects.	Where permitted, target texture/appearance, edge protection and subsequent cleaning/treatment.

ASTM publishes separate scopes for chemical passivation in A967/A967M-25 [15] and passivation using electropolishing in B912-26 [16]. This guide has reviewed the public records, not performed a clause-by-clause review of the purchased standards. A compliant instruction requires the agreed full requirements.

For a precision stainless seat, specify the final geometry and texture after the whole route. If a removal process changes an edge, bore or sealing land, an attractive finish is not proof that the feature is acceptable. For corrosion duty, keep grade selection, contamination control and service exposure in the same review.

> **A PRACTICAL ACCEPTANCE SPLIT**
>
> Record appearance, texture, geometry and process-verification evidence separately. A photograph cannot establish all four, and one certificate should not be described as doing so.

Sources: [15] ASTM International | [16] ASTM International

20 / NI-P PLATING DECISIONS

Electroless nickel adds another material system

Do not specify a metallic deposit by its color alone or assume every deposit has the same properties.

Specify or resolve	Reason it matters
Substrate and its final state	Preparation, adhesion, dimensions and later heat exposure must be compatible with the base material.
Deposit identity and composition class	The intended phosphorus range and process class affect what is being purchased.
Thickness and measurement locations	The deposit changes dimensions; access and local geometry still need review.
Post-plating treatment	Define the approved route and its effect on both the deposit and the substrate.
Functional duty	Sliding/wear, contact, corrosion or another function needs its own acceptance criterion.
Protected areas and final limits	Threads, fits, sealing lands and electrical features must be accepted after the complete route.

NASA's public electroless-nickel reference treats deposit classification, thickness, post-treatment and quality verification as separate requirements [17]. Its document is technical context, not a blanket process authorization for a vetcnc part. Confirm the controlled edition and a qualified process for the actual substrate.

A fit example with a simple deposited layer

For an original screening example, assume a shaft is 9.980 mm before plating and the validated net deposit adds 0.008 mm radially on each side. The final diameter is 9.980 + 2 x 0.008 = 9.996 mm. If deposit variation and preparation removal are not known, the nominal result cannot establish compliance with a fit tolerance.

A post-treatment selected to change deposit hardness may also expose the base material to a consequential thermal cycle. Ask the process and materials owners to review the complete sequence, especially where heat-treated alloys or embrittlement-sensitive conditions are involved. Do not invent a generic baking or heat-treatment recipe.

> **COMPARE COMPLETE ROUTES**
>
> If one offer includes the required thickness verification and post-treatment while another does not, the quoted surfaces are not yet equivalent.

Sources: [17] NASA / JSC | [20] NASA / JSC

21 / PROCESS INTEGRATION

The sequence determines the delivered condition

A finish choice is incomplete until it has a place in the manufacturing and verification sequence.

MACHINE → PREPARE → TREAT → VERIFY → PACK

Every later operation can change the earlier result. Protect critical surfaces, control rework and verify the delivered condition.

Sequence risk	What to put in the release or review
Final machining after a protective treatment	Identify the newly exposed surface, its required protection and the permitted repair/touch-up route.
Blasting near a precision edge or seat	Define protected zones and final acceptance; "same nominal dimension" is not proof that the contact edge survived.
Heat treatment after final sizing	Plan distortion allowance and final verification; do not accept a pre-treatment report as the final geometry report.
Repeated stripping and refinishing	Require authorization and a review of dimensions, surface state and traceability before rework.
Residue left in blind features	Define the final cleaning/drying and packaging condition appropriate to the application.

For IH-150, a proposed route is: machine the released geometry; inspect critical pre-treatment features; prepare and mask the agreed zones; apply the approved surface process; remove masking and clean; verify final dimensions, interfaces and appearance; then package to protect the surfaces. This is a sequence concept, not a process recipe.

Place intermediate inspections where they prevent consequential later work. Discovering a wrong bore before treatment avoids the added loss of finishing and assembly; not every requirement needs duplicate inspection.

MAKE A LATER CHANGE VISIBLE

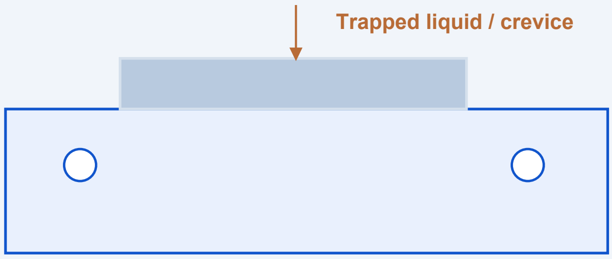
Switching the preparation method, finisher, stock temper or post-treatment can change the result without changing the CAD model. Decide which changes require requalification and written approval.

Sources: [05] Carpenter Technology | [12] Ensinger | [13] NASA / JSC | [17] NASA / JSC

22 / AN EVIDENCE-BASED CORROSION DECISION

Case B: the washdown block stays on hold

WB-40 demonstrates why a clear hold can be a better engineering decision than an unsupported material recommendation.



Review the joint as well as the grade.

Cleaner + concentration + temperature
Contact time + rinse + drainage

Known teaching condition	Action / disposition
Cleaner X: 2%, 50 C, 20 minutes per cycle	Obtain composition and approved-use information; concentration and temperature alone do not establish compatibility.
Liquid can remain under a gasket	Review the actual joint and drainage. An open flat coupon is not the only relevant test geometry.
304L and 316L are proposed	Use them as candidates, not approved selections. Resolve environment and surface route before comparing final economics.
No verified corrosion acceptance limit yet	The design owner defines permitted attack, affected zones and required service/cleaning exposure before testing.

A useful test request

WORKED WORDING

"Test the candidate material and finish with the actual cleaner, rinse, temperature and contact duration. Include a representative joint and an unexposed control. Assess appearance, dimensions and surface damage against pre-approved criteria."

If the chemistry is unsuitable or the joint test fails, reconsider the material, cleaner, drainage or joint design. Do not change the test merely to obtain a pass. A successful short exposure is not a lifetime prediction.

DECISION AT THIS STAGE

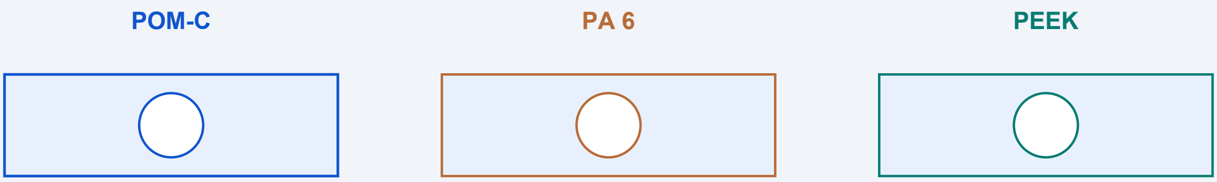
HOLD release until chemistry, candidate review, criteria and representative results are resolved. Neither stainless grade has passed this teaching case.

Sources: [03] Outokumpu | [04] Outokumpu | [18] Outokumpu

23 / A PRECISION LOCATOR AT 23-60 C

Case C: a better polymer still needs a better interface

PL-100 has a 100 mm polymer span against an aluminum carrier. The fictional movement allowance is 0.05 mm.



Use the same geometry for screening, then redesign and test the actual constrained assembly.

Assume the parts are located together at one end and free to move axially at the other, with uniform temperature changing from 23 to 60 C. Use delta T = 37 K. For this first-order screen, use the longitudinal CLTE values from page 10 and 23.6 x 10^-6 /K for the aluminum carrier.

100 mm span	Free growth / mm	Relative to aluminum / mm
6061 carrier	0.08732	Reference
POM-C example	0.48100	0.39368
PA 6 example	0.44400	0.35668
PEEK example	0.18500	0.09768

All three unchanged polymer candidates exceed the 0.05 mm differential-movement allowance in this nominal free-expansion model. PEEK improves the result, but its 0.09768 mm difference still fails the stated screen. Choosing the more expensive material alone is not an adequate resolution.

Now propose a 20 mm effective locating span with a guided floating feature elsewhere. The same PEEK/aluminum differential becomes 20 x (50 - 23.6) x 10^-6 x 37 = 0.019536 mm. That leaves about 0.03046 mm of the teaching allowance for other effects. Confirm that this geometry still performs the locating function and then test the actual tolerances, constraints, load and conditioning.

DECISION AND NEXT EVIDENCE

Carry the revised interface forward for prototype evaluation, not immediate production approval. If the part is fully restrained, analyze the resulting loads; the free-expansion subtraction is no longer the complete model.

Sources: [01] Kaiser Aluminum | [09] Ensinger | [10] Ensinger | [11] Ensinger

24 / WORKED INSTRUCTION STRUCTURE

Turn the selected route into a finish specification

A useful instruction tells the supplier which document controls the process and what must be true on delivery.

Weak note	More useful worked instruction
"Black anodize."	IH-150 exterior zone 1: use the approved process document FIN-IH150 Rev A; preparation, color/seal, thickness limits and inspection locations are defined there.
"Mask important areas."	Protect zones 2-4 to the boundaries and transitions in the released drawing. No unapproved coating or residue on designated contacts.
"Good appearance."	Evaluate visible zone 1 against approved sample IH-COLOR-01 under the agreed viewing conditions; define rejectable defects and permitted rack marks.
"Tolerances before coating."	Critical interface limits apply to the delivered part after all operations unless a specific intermediate requirement is labelled.
"Certificate required."	Provide a record linking part/revision, process issue, treatment lot and agreed verification. Include specified actual measurements separately.

The document names above are original teaching references, not attached process specifications. A real FIN-IH150 record must actually contain the selected standard/revision, substrate, process classification, preparation, thickness and variation, masking map, post-treatment, acceptance and verification. A reference to an empty or missing record adds no rigor.

What remains with the technical owner

The designer owns required function and final feature limits. The qualified process route establishes how the finish is produced. Inspection confirms the ordered characteristics using agreed methods. Those responsibilities must meet in one consistent release; neither a sales quote nor a cosmetic sample silently replaces the engineering definition.

> **DO NOT ISSUE BRACKETED UNCERTAINTY AS A SPECIFICATION**
>
> If thickness, process or masking is still undecided, mark it OPEN in the review and request a proposal. Do not let an incomplete example become an apparently approved production note.

25 / A PRACTICAL TEST MATRIX

Validate the failure modes, not only the appearance

Use the simplest justified test that can discriminate between acceptable and unacceptable behavior.

PASS	HOLD	REJECT
Evidence meets criterion	A critical answer is open	Required function fails

Concern	Representative evidence	What a pass would not prove
IH-150 mechanical interface	Defined load and mount; displacement and retained geometry versus approved limits.	Fatigue life or untested loads.
Thermal fit / PL-100 motion	Actual locating constraints and temperature cycle; measure relative movement.	Other temperatures, moisture states or permanent aging behavior.
Coated bore / thread	Final feature measurements and agreed functional verification after treatment.	Every unmeasured location or long-term wear.
WB-40 cleaning exposure	Defined chemistry, cycle, joint and acceptance; inspect relevant damage.	Unlimited service life or compatibility with another cleaner.
Electrical contact	Actual counterpart and assembly condition; agreed resistance test, including required exposures.	A complete product electrical-safety qualification.

Set criteria before testing. Retain sample identity, revision, stock/finish lot, setup, exposure, method and actual result. "Looked fine" is inadequate evidence for a later production investigation.

ISO 9227 explicitly limits the use of salt-spray methods for ranking different materials and predicting long-term corrosion resistance [19]. Do not convert a quoted salt-spray duration into years of service. Select the test for the question, and document what remains outside its evidence.

AN HONEST RELEASE RECORD

Record PASS, HOLD or REJECT for each mandatory gate. A missing critical test is HOLD. An approved deviation needs its own authority and scope; it should not be relabelled a normal pass.

Sources: [19] ISO

26 / TROUBLESHOOTING THAT GUIDES THE NEXT CHECK

When the part fails, separate the possible causes

A symptom is evidence to investigate, not a reliable material diagnosis by itself.

Symptom	Plausible causes to separate	Next useful evidence
Bore or thread tight after finishing	Net build-up, masking error, preparation variation, incorrect pre-size.	Compare pre/post measurements, feature identity and treatment/mask records.
Stainless stains after cleaning	External contamination, unsuitable exposure, trapped liquid or a surface-process issue.	Identify deposits/chemistry, inspect the joint and trace cleaning/treatment history.
Aluminum colors do not match	Different alloy/stock, preparation, process route or sample/viewing conditions.	Compare lot and route records with representative approved samples.
Polymer dimension drifts	Temperature, moisture, stress relaxation, load or changed conditioning.	Repeat controlled measurements while isolating those variables.
Plate moves after unclamping	Residual stress, an asymmetric removal route, fixture influence or thermal effects.	Check free-state results at defined stages and map the actual process.
Electrical contact unstable	Unintended coating, residue, assembly variation or exposure effects.	Inspect the pad and test the defined assembled interface, not only loose material.

Contain suspect parts and preserve their records before reworking them. A stripped coating, polished stain or forced thread can erase useful evidence. The technical owner should decide what testing is necessary and which remedies are authorized.

Change one explanatory variable at a time where practical and retain a control. If the supplier changes material, finisher, masking and measurement method together, an improved sample may still leave the production cause unresolved.

DO NOT JUMP FROM SYMPTOM TO GRADE CHANGE

A more expensive alloy will not necessarily fix a preparation error, a trapped-fluid joint or an inspection-state mismatch. Confirm the mechanism before approving the remedy.

Sources: [12] Ensinger | [13] NASA / JSC | [18] Outokumpu

27 / WORKED ECONOMIC SCREEN

Price the material-and-finish route as a system

These fictional amounts demonstrate arithmetic and scope control, not market prices or vetcnc quotations.

50-part teaching lot / USD	Route A	Route B
Machined bodies	50 x 24 = 1,200	50 x 27 = 1,350
Surface-treatment lot charge	180	Included in body package
Defined masking / handling	90	Included in body package
Required verification record	80	80
Special surface-protection packing	50	50
Comparable subtotal	1,600	1,480
Subtotal / 50 accepted pieces assumed	32.00	29.60

Assume both routes have already met the same technical gates and include the same approved material, final surfaces and evidence. Route A starts with a lower body price, but 1,200 + 180 + 90 + 80 + 50 = 1,600. Route B is 1,350 + 80 + 50 = 1,480, or USD 120 lower on this boundary. Freight, taxes and buyer-side work are excluded from both.

Show uncertainty instead of hiding it

If a new finish route needs a one-time USD 400 qualification, the cost model must include it in the relevant decision. Over 50 pieces it adds USD 8 per piece; over 500 it adds USD 0.80, assuming the same qualification legitimately covers the larger program. That is a scope assumption, not permission to spread unrelated future costs away.

Do not invent scrap rates to produce a preferred ranking. Request the actual lot minimums, repeat charges, qualification scope, inspection cost and delivery constraints. A change in stock form or finishing batch size may alter both unit cost and risk.

> **TECHNICAL ELIGIBILITY COMES FIRST**
>
> These totals are not comparable if one route omits the conductive pad, uses a different polymer grade or excludes the required finished-bore verification.

28 / THE HOUSING BRIEF

A completed material-and-finish inquiry

Use this structure after the functional duty is understood; send the actual referenced documents, not this example alone.

WORKED WORDING

To: ruofan@ruojufanxing.com
Subject: IH-150 prototype review - material and finish route

Hello vetcnc team,

Please review our released IH-150 concept and propose a manufacturing route for the prototype evaluation. The provisional material is 6061-T651 plate to the product specification in our requirements register. Identify the actual stock and evidence offered; list substitutions separately.

The body-only mass allowance is 0.50 kg. Our current net volume is 150 cm3. Service is the defined indoor 20-60 C duty. The mechanical interface and differential thermal movement remain prototype-validation gates, not assumed passes.

The drawing separates the cosmetic exterior, thermal seat, bonding pad and threaded features. Please propose the compatible surface sequence, preparation, masking boundaries, rack locations and final verification against those zones. Resolve the process specification and appearance sample before treatment.

Identify cost, lead-time and feasibility effects of each proposed alternative. No change to material, geometry, contact condition or final feature limit is authorized until our controlled release is updated.

Please flag missing information and confirm the received revision.
[Your name and company]

Attach the actual drawing/model register, material requirements, service/exposure statement, finish-zone definition and prototype acceptance plan. Keep proprietary information within the approved sharing route. A supplier cannot confirm a hidden interface or an unspecified test criterion.

WHAT THIS INQUIRY INTENTIONALLY DOES NOT CLAIM

It does not claim the alloy, finish or complete assembly has already passed. It asks for a defined prototype route with explicit approval gates, so a useful technical response can precede production commitment.

29 / COMPACT DECISION CHECKLIST

The ten checks to keep beside your drawing

Use this page to review a selection record, not to replace the engineering behind it.

Check	A complete answer looks like this
01 / Function	Failure mode and measurable requirement are named.
02 / Environment	Chemistry, temperature, duration, joints and maintenance are defined.
03 / Material identity	Grade, state, product form and governing purchasing requirements agree.
04 / Data context	Typical/minimum status, units, test state and source are retained.
05 / Geometry screen	Mass, stiffness, fit and thermal movement use the actual candidate design.
06 / Surface map	Each functional zone has a clear process/protection instruction.
07 / Final condition	Critical dimensions and interfaces are accepted after the complete route.
08 / Process sequence	Heat, preparation, treatment, rework and packaging are coordinated.
09 / Evidence	Prototype/inspection criteria, part identities and actual results are traceable.
10 / Release	Mandatory gates pass or have an authorized disposition; open items remain visible.

Three questions that catch expensive omissions

What changes if the part gets wet or warm? Which surface treatment could contradict an interface? What published number are we treating as a guarantee without justification? If the answers are unclear, the next step is a targeted review or test, not a more confident material label.

> **A GOOD SUPPLIER CONVERSATION STARTS HERE**
>
> Share the function and constraints, identify allowed alternatives, and ask for the evidence needed to close the decision. The result should be one coherent, approved definition of the delivered part.

APPENDIX / REUSABLE FORM

Your material and finish decision brief

Use the completed housing brief on page 30 as a model. Attach detailed requirements by controlled reference.

Part / revision / quantity

Function / load / permitted movement

Temperature / chemicals / exposure

Grade / state / product specification

Finish process / drawing zones

Final limits / masked features

Validation / inspection evidence

Open decisions / owner / due date

Decision, approved alternatives and release-document references

- [ ] No critical unknown is treated as a pass.
- [ ] Grade, process, dimensions and tests refer to the same revision.

Save and reopen in a form-capable PDF reader. This form does not submit data or authorize a material substitution.

REFERENCE REGISTER / 1

Sources and how to use them

Primary-source records checked 20 September 2026. Titles link to the publisher; examples and drawings are original.

[01] Kaiser Aluminum

6061 sheet, coil and plate - technical data

Selected typical properties, not minimum design values. The published sheet is Rev. 05/06; confirm current procurement data for the actual stock.

[02] Kaiser Aluminum

7075 rod and bar - technical data

Typical T6/T651 yield and modulus; temper tradeoffs. Rod/bar data are not a certificate or plate-property guarantee.

[03] Outokumpu

Core range - stainless steel datasheet

Grade-family and 304/304L context. Product form, condition and specification determine the applicable purchased properties.

[04] Outokumpu

Supra range - stainless steel datasheet

316L/4404 physical data: density, elastic modulus and expansion; environment and product-form limits. Do not transfer flat-product strength limits to bar.

[05] Carpenter Technology

Custom 630 (17-4) - datasheet

Age-hardening condition, property tradeoffs and dimensional change. Not a standalone furnace instruction or universal allowable.

[06] TIMET

TIMETAL 6-4, 6-4 ELI and 6-4-.1Ru

Physical-property reference, Table 2. This legacy manufacturer sheet distinguishes Grades 5, 23 and 29; its historical specification editions are not procurement defaults.

[07] Copper Development Association

C11000 - alloy record

ETP copper identity, physical properties and conductivity context. Temper, product form and actual evidence remain necessary.

[08] Copper Development Association

C36000 - alloy record

Free-cutting brass composition and conductivity. Contains lead; this reference does not establish regulatory eligibility for an application.

REFERENCE REGISTER / 2

Sources and how to use them

Primary-source records checked 20 September 2026. Titles link to the publisher; examples and drawings are original.

[09] Ensinger

TECAFORM AH natural - unfilled POM-C

Named stock-shape reference for density, tensile modulus and longitudinal CLTE. Typical test data are not guaranteed part behavior.

[10] Ensinger

TECAMID 6 natural - PA 6

Named unfilled PA 6: density, modulus, CLTE and time-specific water uptake. Water uptake by mass is not dimensional strain.

[11] Ensinger

TECAPEEK natural - unfilled PEEK

Named stock-shape density, modulus and longitudinal CLTE. Service-temperature listings are not precision-under-load guarantees.

[12] Ensinger

Frequently asked questions - machinable plastics

Manufacturer guidance on moisture, stress relaxation, temperature, conditioning and orientation. No universal annealing schedule or shrinkage allowance is adopted.

[13] NASA / JSC

PRC-5006 - anodizing, public Rev. D copy

Technical discussion of anodizing, masking and dimensional effects. This older PDF is not the latest revision listed in [20]; no process defaults are adopted.

[14] NASA / JSC

PRC-5005 - conversion coating, public Rev. D copy

Distinguishes conversion-coating classes and electrical-resistance intent. Use [20] to check revision status; the page does not qualify a supplier.

[15] ASTM International

A967/A967M-25 - chemical passivation

Public scope of chemical passivation treatments and verification. This guide does not reproduce the full standard or select a chemical treatment for all grades.

REFERENCE REGISTER / 3

Sources and how to use them

Primary-source records checked 20 September 2026. Titles link to the publisher; examples and drawings are original.

[16] ASTM International

B912-26 - passivation using electropolishing

Current public catalogue scope, checked at publication. Electropolishing and chemical passivation are not interchangeable purchase descriptions.

[17] NASA / JSC

PRC-5007 - electroless nickel, public PDF

Technical guidance on Ni-P deposit, classification and post-treatment. The public copy predates the PRC-index revision; verify the contractual process separately.

[18] Outokumpu

What makes stainless steel corrosion resistant?

Environment-dependent corrosion, pitting/crevice considerations and dissimilar-metal coupling. Not a compatibility rating for a named cleaner.

[19] ISO

ISO 9227:2022 - salt spray tests

Public scope and explicit limitations on material ranking and long-term corrosion prediction. Test details require the agreed full standard.

[20] NASA / JSC

Structural Engineering Division - PRC index

Revision-status cross-check: the index lists newer revisions than the three public copies used for technical context. Follow the applicable controlled issue.

[21] MIT OpenCourseWare

3.032 - Problem Set 1 solutions

Reference for the clamped-free, tip-loaded elastic beam formula. Geometry, loading, numerical examples and figures in this guide are original.

[22] NIST

Engineering Metrology Toolbox - dimensional FAQ

Dimensional reference temperature and measurement context. Thermal screening in this guide is not a complete measurement-uncertainty budget.

NASA public PDF copies cited here predate revisions listed in its PRC index [20]. They support technical principles, not current contract approval. Standards catalogue entries are not full standards. Confirm the agreed edition, full requirements and engineering review before release.

vetcnc
CNC MANUFACTURING

FROM A MATERIAL NAME TO A CLEAR REQUIREMENT

Bring the application.
Make the tradeoffs clear.

Share your current drawing and the service conditions that make the part difficult. State what is fixed, what may change, and what still needs evidence.

01 **FUNCTION**

Loads, interfaces, allowable movement and expected life.

02 **CONDITION**

Grade, material state, treatment and protected surfaces.

03 **EVIDENCE**

Required records, prototype checks and release criteria.

---

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