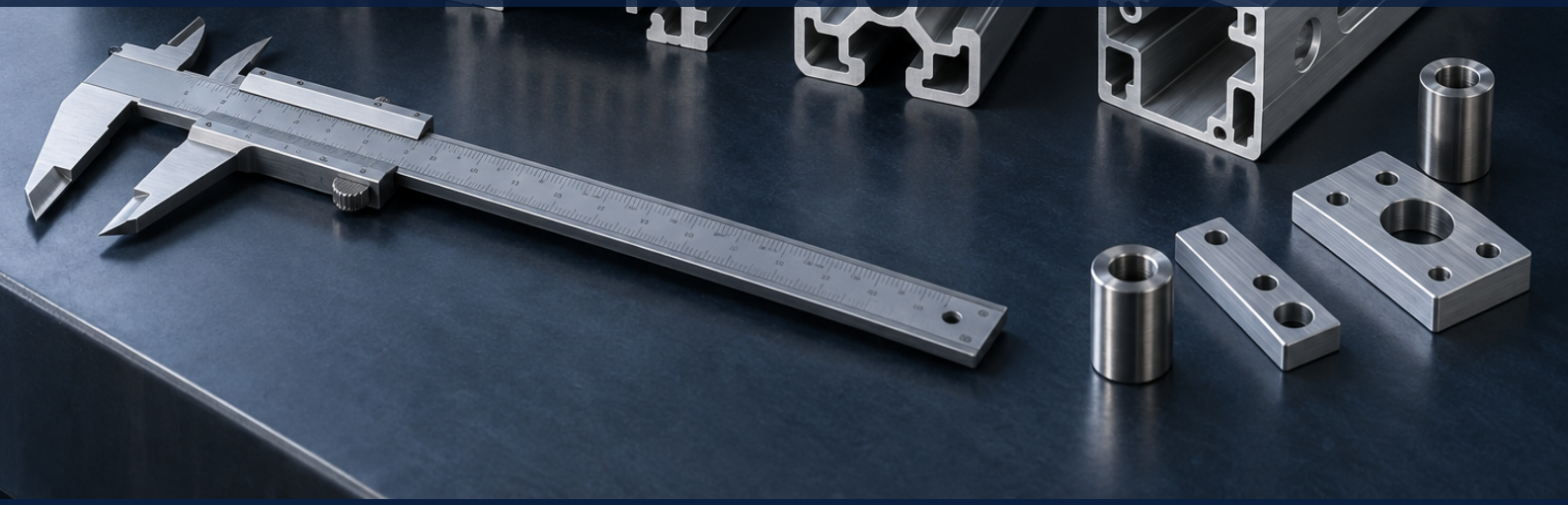
DESIGN FOR MANUFACTURING

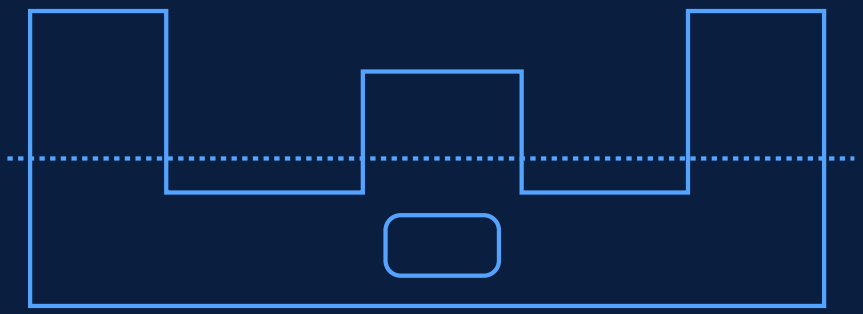
CUSTOM ALUMINUM EXTRUSION DESIGN GUIDE

Profile geometry | Tooling | Tolerances | CNC machining | Finishing



A practical engineering handbook for production-ready aluminum profiles

From continuous function and metal flow to cut-off, machining and final inspection



Prepared by BAOSONG

baosongprecision.com

Version 1.0 | September 2026 | Metric-first

Conceptual manufacturing image - not a capability statement

00 Design Logic and Contents

Build continuous function into the profile, then control the complete route from die release to finished-part inspection.

CORE PRINCIPLE

A production-ready extrusion is not only a CAD cross-section. It is a balanced shape that can flow through a die, cool and straighten predictably, accept finishing, provide machining stock and be inspected from useful datums.

The four design layers

LAYER	PRIMARY QUESTION	RELEASE EVIDENCE
Function	Which loads, interfaces, heat paths, seals, fasteners and appearance zones run along the part?	Interface map and critical-to-function list
Profile	Are walls, hollows, tongues, radii, ribs and material distribution practical?	Extruder-reviewed cross-section and classification
Process	What happens after extrusion: straighten, cut, machine, finish, join or assemble?	End-to-end route with allowances and protected surfaces
Verification	How will cross-section, long-form geometry, finish and machined features be accepted?	Datum, method, condition, sampling and report plan

Guide map

01 How Extrusion Creates Variation

The profile exits a shaped die hot, then cools, stretches or straightens and is cut to length.

Metal flow, cooling, stretching/straightening and cut-off create the as-extruded condition.

1.1 Design around the real process chain

Metal flow through the die establishes the continuous section. Cooling, quenching, handling, stretching, aging and cut-off influence dimensions, straightness, twist, surface and mechanical properties. A nominal CAD section does not describe every permissible production condition.

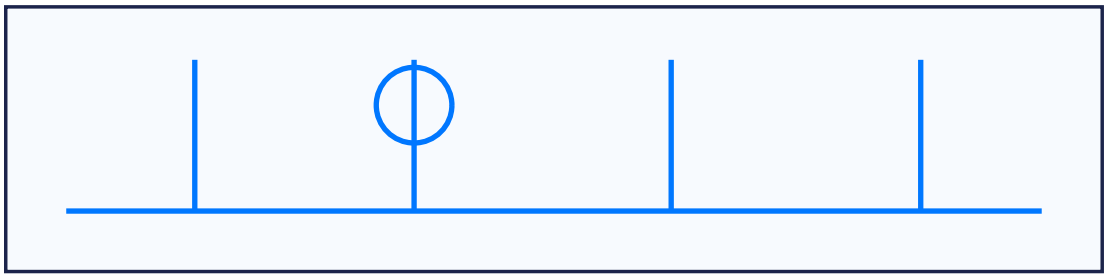
STAGE	DESIGN CONSEQUENCE	CONTROL QUESTION
Billet and alloy	Chemistry and extrusion response affect flow, properties and finish.	Which alloy, temper route and material standard govern?
Die and flow	Different wall masses and unsupported die features resist flow differently.	Are walls balanced and die tongues supported?
Cooling and straightening	Thermal contraction and correction affect long-form geometry.	What straightness, twist and support condition matter?
Cut-off and handling	Saw cut, burrs and contact can change end use and appearance.	Is the cut end functional, cosmetic or only stock?

DO NOT TRANSFER CNC EXPECTATIONS

As-extruded cross-sectional and long-form tolerances belong to the agreed extrusion product standard. Local precision interfaces may need secondary machining.

02 Function Map: Extrude or Add Later

Use extrusion for features that earn their value by continuing along the length.



LOAD FASTEN CABLE SEAL DATUM

FEATURE	NATURAL EXTRUSION CANDIDATE	BETTER AS SECONDARY OPERATION WHEN...
Wall, rib or rail	It repeats continuously and supports load, alignment or enclosure.	It is local, version-specific or needs a precise end relationship.
Channel or groove	It guides cables, seals, hardware or sliding elements along length.	Its local depth or location must reference a machined datum.
Boss or screw port	It reduces added hardware and repeats at every cross-section.	Engagement, thread class or edge condition needs machining and validation.
Pocket or transverse hole	Rarely - extrusion does not create isolated transverse geometry.	Usually drill, mill, punch or route after cut-off.
Precision sealing/bearing land	The profile can provide stock near the final surface.	Size, form or location exceeds practical as-extruded control.

2.1 Simplify the assembly, not just the part

- Combine brackets, covers, rails or wire paths only when the continuous feature reduces total operations.
- Keep local product variants out of the die where machining or modular hardware is more flexible.
- Mark keep-out zones and future machining access before the section is frozen.

SERVICE LINK Review the complete route with BAOSONG custom aluminum extrusion services.

03 Alloy, Temper and Product Route

Choose the material for extrusion, strength, finishing, machining, joining and service together.

CANDIDATE	COMMON DESIGN REASON	EARLY REVIEW
6063	Often considered for good extrudability, complex profiles and decorative anodized appearance.	Required strength, wall/shape complexity, finish sample and product form.
6061	Often considered when structural properties or downstream machining carry more weight.	Section feasibility, temper/property route, finish consistency and machining distortion.
6005A / 6082	May be considered for structural extrusions in markets where specified and available.	Regional standard, property limits, weld design and supplier availability.
Other alloys	Electrical, thermal, high-strength or corrosion needs may justify alternatives.	Extrudability, die wear, quench sensitivity, finish response and qualification.

3.1 Temper is not a cosmetic suffix

T5, T6 and other tempers identify different processing histories and property conditions. The selected alloy-temper combination must be available for the profile thickness, geometry and qualification route. Do not substitute a temper because a catalog strength appears similar.

3.2 Define the complete material condition

- Alloy designation, temper, governing material standard and edition
- Mechanical-property requirements and test orientation where applicable
- Product-form and lot-traceability expectations
- Welding, bending, machining, heat exposure and final finish

AUTHORITY

Use the current Aluminum Association standards resources and the contract-specified material document; supplier review is still required.

04 Envelope, CCD and Press Economics

Profile size, weight per length and complexity interact with available press and tooling routes.

4.1 Circumscribing circle diameter

The circumscribing circle diameter (CCD) is the smallest circle that encloses the cross-section. It is a useful first description of profile envelope and press compatibility, but it does not prove feasibility. Wall distribution, weight per length, alloy, tolerances and order quantity also matter.

INPUT	WHY IT MATTERS	DESIGN MOVE
CCD / envelope	Influences die size and available press family.	Compact, split or reorient the section if function allows.
Area and mass per length	Affects billet use, press productivity, handling and cost.	Remove material that has no structural, thermal or process purpose.
Perimeter-to-area behavior	Long thin perimeters can be difficult to flow and cool uniformly.	Use balanced walls, ribs and less extreme slender detail.
Order length and quantity	Affects billet plan, recovery, straightening, cut-off and tooling economics.	Provide annual demand, cut lengths and acceptable recovery assumptions.

GUIDANCE, NOT A PASS/FAIL LIMIT

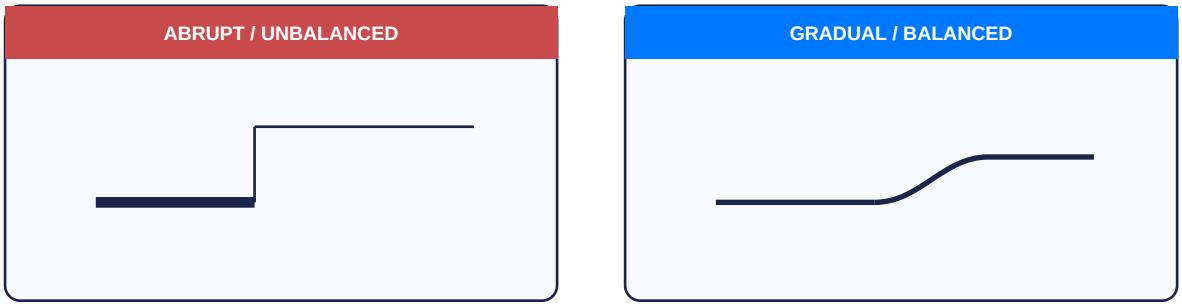
AEC identifies CCD, weight per length and press availability as key economic factors. See AEC extrusion design considerations and confirm the actual press/tooling route with the selected extruder.

4.2 Split versus one-piece profile

- Split the section when it reduces a difficult hollow, improves die support or separates cosmetic and structural requirements.
- Keep one piece when it removes joints, fasteners or leak paths and the die remains practical.
- Compare total assembly cost, not tooling price alone.

05 Wall Thickness and Metal-Flow Balance

Uniformity is a design objective, not a universal minimum-wall rule.



Balanced walls support more uniform metal flow and cooling. Abrupt thick-to-thin changes can contribute to uneven flow, surface effects and dimensional variation. The practical wall range depends on alloy, CCD, wall length, die support, press, tolerance and order economics.

CONDITION	RISK	PREFERRED REVIEW
Very thin long wall	Flow resistance, cooling sensitivity, denting and straightening difficulty.	Shorten unsupported length, add rib, increase thickness or change orientation.
Heavy local mass	Different flow speed, thermal contraction and finish response.	Core out nonfunctional metal or transition gradually.
Asymmetric mass	Unequal flow and distortion correction burden.	Rebalance material or identify the functional face and allowed correction.
Machining stock pad	Too little stock may disappear within extrusion variation; too much adds mass and cutting.	Size from the actual stock envelope and fixture datum plan.

NO GENERIC MINIMUM

Do not approve a minimum wall from an online rule alone. Mark function-driven walls and ask the extruder to review the complete section, alloy, tolerance and volume.

06 Radii, Tapers, Symmetry and Edge Conditions

Smooth transitions protect metal flow, die durability, stress distribution and finish consistency.

DETAIL	DESIGN INTENT	CHECK BEFORE RELEASE
Internal radius	Avoid a zero-radius transition and reduce abrupt flow/stress concentration.	Mating clearance, tool/die construction, wall thickness and visible edge.
External corner	Prevent knife edges and fragile tips; improve handling and coating coverage.	Cosmetic sharpness, anodizing response and downstream deburring.
Taper	Ease flow into changing wall regions and reduce abrupt section changes.	Functional envelope and accumulated dimensional variation.
Symmetry	Support balanced flow and cooling where product function permits.	Do not add symmetry that wastes material or harms assembly.
Asymmetric profile	Can be valid when function requires it.	Identify dominant mass, die correction strategy, twist risk and datum face.

6.1 Separate visual and dimensional edge requirements

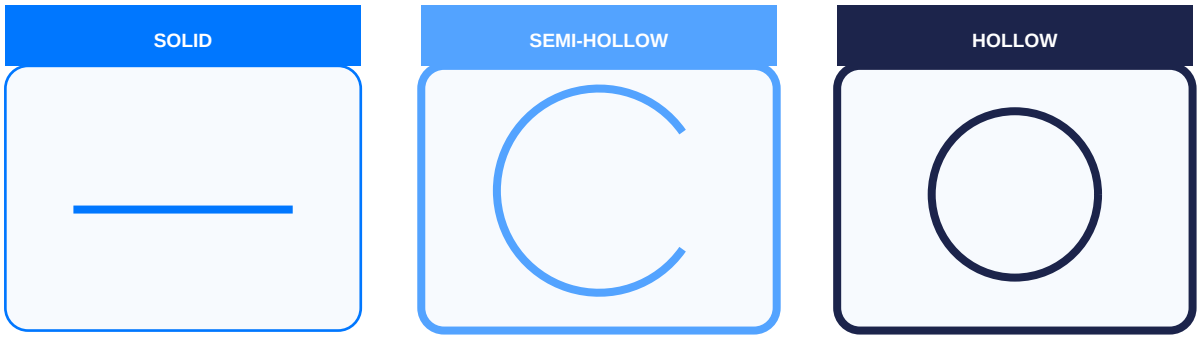
A CAD edge may represent a functional contact, a safe-to-touch break, a cosmetic line or merely a nominal boundary. State which condition matters. Extrusion, cut-off, tumbling, brushing, machining and coating can each change the final edge.

PRACTICAL DETAIL

AEC recommends smooth transitions, generous radii and avoiding knife edges. Treat its design tips as optimization guidance, then validate the project-specific geometry.

07 Solid, Semi-Hollow and Hollow Sections

Profile classification changes die concept, metal-flow challenge, tolerance treatment and tooling economics.



CATEGORY	DESCRIPTION	DESIGN CONSEQUENCE
Solid	No completely enclosed void; may still contain open channels.	Simpler die concept in many cases, but deep open channels can create severe tongues.
Semi-hollow	Partially enclosed void whose classification depends on geometry and the governing definition.	Do not classify by appearance alone; applicable tooling and tolerance rules may differ.
Hollow	One or more fully enclosed voids.	Requires a hollow-die concept, weld chambers/ports and careful flow balance.

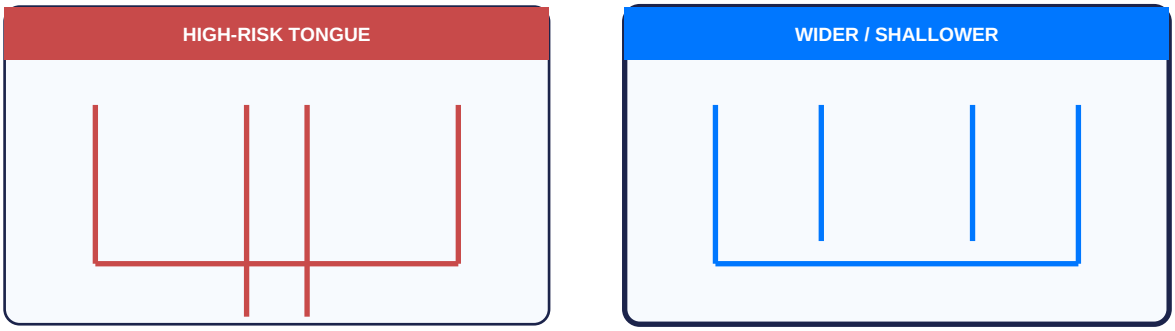
7.1 Ask whether the enclosed space earns its complexity

- Does the void provide stiffness, fluid flow, wire routing, thermal function or assembly value?
- Could an open section plus cover, seam or inserted component meet the same requirement?
- Can the void be drained, cleaned, finished and inspected as required?
- Will transverse machining expose internal seams or unsupported walls?

CLASSIFICATION	Have the extrusion supplier confirm solid, semi-hollow or hollow classification before quotation and tolerance selection.

08 Tongues, Channels and Fins

Depth, opening width, root support and surrounding flow determine die-feature risk.



A deep narrow channel creates a slender die feature commonly called a tongue. Increasing depth while reducing opening width reduces support and can increase deflection, breakage, correction and tolerance difficulty. No single tongue-ratio number applies to every alloy, die and press.

IF THE FEATURE IS DIFFICULT	DESIGN ALTERNATIVES	FUNCTION TO RECHECK
Deep narrow channel	Widen opening, reduce depth, change orientation or split the assembly.	Cable, seal, slide, fastener and enclosure requirement.
Tall thin fin	Increase thickness, reduce height, add base support or adjust spacing.	Heat-transfer analysis, airflow and cleanability.
Narrow slot with sharp root	Add root radius/taper and open the mouth where possible.	Mating insert retention and final corner need.
Repeated dense fins	Remove nonfunctional fins or vary geometry around flow balance.	Thermal gain versus pressure drop, mass and tooling risk.

EARLY REVIEW Tongues and fins are among the details where a small geometry change can materially change die risk. Review before the interface dimensions are locked.

09 Ribs, Grooves, Screw Ports and Datum Pads

Continuous details should serve stiffness, assembly, indexing, machining or finish control.

FEATURE	USEFUL PURPOSE	DESIGN / VALIDATION QUESTION
Rib or web	Increase local stiffness, stabilize a broad wall or guide straightening.	Does thickness and junction geometry preserve balanced flow?
T-slot / capture groove	Locate hardware or support adjustable assembly.	Are throat, internal space, insertion path and finish buildup controlled?
Screw port	Support end fastening without a separate nut or insert.	Fastener engagement, edge distance, torque, fatigue and service cycles?
Index groove	Guide drilling, punching or assembly orientation.	Is it a process aid or a controlled product feature?
Datum pad / rail	Create a broad repeatable surface for fixturing and inspection.	Will the pad remain accessible after cut-off and finishing?
Snap / hinge detail	Reduce part count and assembly hardware.	Tolerance stack, force, fatigue, temperature and removal life?

9.1 Avoid redundant CAD dimensions

Dimension the functional opening, material condition or interface. Long chains across ribs, walls and spaces can over-constrain the profile or create conflicting acceptance paths. Identify reference dimensions clearly.

DESIGN REVIEW

Use BAOSONG engineering support to review profile detail, downstream operations and inspection as one route.

10 Tolerance Categories

Cross-sectional size, wall thickness and long-form geometry describe different kinds of variation.

CATEGORY	WHAT IT CONTROLS	DRAWING / INSPECTION INPUT
Metal dimension	Distance through or substantially occupied by material.	Identify functional thickness, stock or strength reason.
Space dimension	Opening, channel or distance substantially occupied by space.	Control the mating envelope rather than redundant wall chains.
Wall thickness / eccentricity	Material around a rib, wall or enclosed space.	Mark critical walls and apply the correct product category/notes.
Straightness	Longitudinal bow over a stated evaluation length.	Length, orientation, support and reference line.
Twist	Rotation of cross-section along the length.	Controlled face, length, support and reporting method.
Flatness	Form across the width of a surface.	Functional face, span, profile classification and setup.
Cut length / squareness	Blank length and the end-face relationship.	Saw-cut or machined state; do not assume one controls the other.

STANDARD AND EDITION

For North American projects, ANSI H35.2/H35.2M-2024 is a current Aluminum Association tolerance reference. Use the contract-specified document, correct product category, notes and units.

10.1 Function-based allocation

- Keep the few critical-to-function requirements explicit.
- Let noncritical characteristics follow the agreed general framework.
- Use CNC machining where a localized relationship needs a different control system.

11 Datums and Inspection

Choose broad, stable and accessible surfaces that represent assembly or downstream machining.

CHARACTERISTIC	POSSIBLE METHOD	SETUP TO DEFINE
Cross-sectional size	Caliper, micrometer, optical system or functional gauge.	Measurement location, local surface condition and finish state.
Straightness	Surface/line reference, indicator, optical or coordinate method.	Evaluation length, orientation, support and allowed restraint.
Twist	Angular/equivalent linear comparison between stations.	Reference face, station spacing, part support and reporting units.
Flatness	Surface plate/indicator, CMM or optical method.	Area, point density, filtering and free/restraint condition.
Machining stock	Profile scan, section gauge or datum-referenced measurement.	Worst stock envelope relative to fixture and final cut.

11.1 Measurement agreement

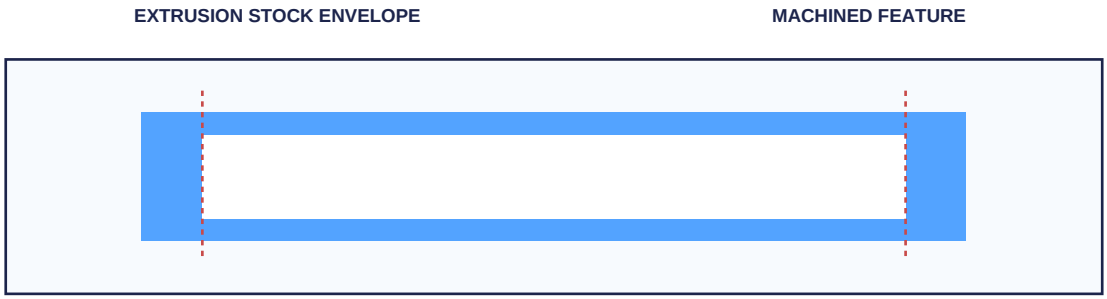
For flexible profiles, results can change with orientation, self-weight and clamping. State whether acceptance is free-state or restrained, how the part is supported and which surfaces simulate assembly. Measurement uncertainty must be suitable for the tolerance and decision rule.

METROLOGY

NIST explains why calibration and uncertainty affect dimensional confidence. See Uncertainty and Dimensional Calibrations and agree the project-specific acceptance method.

12 Cut-Off and CNC Machining

Create local precision from functional datums without assuming nominal extrusion stock is perfectly located.



OPERATION	DESIGN INPUT	COMMON FAILURE
Saw cut	Blank length, burr condition, squareness need and excess for facing.	Treating a rough cut end as a precision assembly datum.
End facing	Final length datum and stock allowance across extrusion variation.	Insufficient stock or excessive removal on bowed/twisted sections.
Cross drilling/tapping	Functional datum rails, clamp access, chip escape and wall variation.	Locating from a flexible lip or uncontrolled cosmetic edge.
Pocket / sealing land	Machining envelope, cutter access, remaining wall and finish sequence.	CAD nominal surface disappears at one stock extreme.
Long-profile machining	Support spacing, distortion, setup transfer and thermal state.	Over-clamping the profile, then accepting it only while restrained.

INTEGRATED ROUTE

Review BAOSONG aluminum extrusion machining and aluminum CNC milling when precise local features must be established after extrusion.

13 Finishing and Cosmetic Control

Appearance and protection depend on alloy, surface preparation, geometry, process and inspection together.

FINISH ROUTE	DESIGN ADVANTAGE	EARLY CONTROL
As-extruded / cleaned	Lowest process complexity where natural mill appearance is acceptable.	Die lines, handling, oxidation, storage and cosmetic zones.
Anodized	Metallic appearance with an anodic oxide surface; clear or colored options.	Alloy/lot, pretreatment, coating requirement, color, sealing, masking and rack points.
Powder coated	Opaque color, texture and broad appearance range.	Pretreatment, powder system, film buildup, cure, edges, holes and touch-up policy.
Brushed / polished	Directional or refined metallic visual language.	Grain direction, access, edge rounding, sample, handling and downstream coating.
Conversion / primer	May support corrosion protection, paint adhesion or electrical design.	Named process, chemistry restrictions, coating system and contact areas.

13.1 Build an appearance map

- Classify primary, secondary, hidden and non-cosmetic surfaces.
- Show grain direction, finish boundaries, rack/contact zones and masking.
- Define color, gloss, texture and allowable marks using production-representative limit samples.
- State which dimensions apply after all finishing.

FINISH LINK Coordinate the complete part with BAOSONG surface finishing and anodized aluminum resources.

14 Joints, Assemblies and Thermal Movement

The profile succeeds only when its mating components tolerate real variation and service conditions.

INTERFACE	STACK CONTRIBUTORS	VALIDATION
Sliding rail	Space dimension, straightness, twist, finish buildup, mating-part size and temperature.	Full engaged length, wear, contamination and assembly-force test.
End screw port	Port geometry, cut squareness, thread forming/cutting, engagement and edge distance.	Torque, strip, fatigue and service-cycle test.
Snap or hinge	Wall flexibility, radius, material/temper, gap, finish and repeated strain.	Assembly/removal force, fatigue, temperature and aging.
Seal channel	Opening, groove form, surface, coating, compression and joint gaps.	Leak, compression set, installation and environmental test.
Thermal path	Alloy conductivity, fin/contact geometry, coating, flatness and interface material.	System-level thermal test, airflow and mounting pressure.
Welded assembly	Alloy/temper, filler, joint access, heat-affected properties and distortion.	Qualified weld route, dimensional plan, NDT and finish trial.

14.1 Thermal scale check

For a 6xxx alloy, a representative thermal expansion coefficient is about 23 um/(m-K), but the actual design value must come from the governing material data. Long profiles can accumulate meaningful movement across temperature change. Provide slots, clearances, seals and joint freedom where service requires it.

ASSEMBLY EVIDENCE

Prototype local interfaces for fit, but use full-length samples when straightness, twist, thermal movement, handling or installation over distance controls the result.

15 Tooling Release and Validation

Close functional, profile, process and verification questions before the die becomes the expensive assumption.

GATE	MUST BE AGREED	OUTPUT
1 Function review	Loads, interfaces, environment, service, appearance and failure modes.	CTQ list and interface map
2 Profile review	Envelope, alloy/temper, wall balance, hollows, tongues, radii, ribs and weight.	Extruder-reviewed section and open-issue log
3 Process review	Die concept, press fit, cooling/straightening, cut-off, machining, finishing and packaging.	End-to-end manufacturing route
4 Verification review	Datums, methods, support/restraint, sampling, appearance samples and reports.	Inspection and approval plan

15.1 Sample approval is configuration-specific

- Record die revision, alloy/temper, profile drawing revision, run condition and sample length.
- Check both cross-sectional and long-form characteristics.
- Process representative samples through machining and finishing before cosmetic approval.
- Do not treat one short sample as proof of full-length twist, straightness or assembly.

15.2 Change control

Define who may approve die correction, alloy/temper substitution, surface-preparation change, finish-system change and inspection-method change. Preserve approved samples and records with revision identity.

16 RFQ Checklist and Contact BAOSONG

Provide enough information to quote the complete profile-to-finished-part route.

MODULE	RFQ / RELEASE CONDITION
Files	[ ] 3D model and controlled 2D profile/part drawings carry the same revision
Material	[ ] Alloy, temper, material standard, property and traceability requirements are stated
Demand	[ ] Sample, batch, annual quantity, profile length and finished cut lengths are provided
Function	[ ] Loads, mating interfaces, CTQs, keep-outs and cosmetic zones are identified
Profile	[ ] CCD/envelope, wall balance, hollows, tongues, radii, ribs and weight are reviewed
Tolerance	[ ] Product standard, edition, category, units and feature-specific controls are stated
Secondary	[ ] Cut-off, machining, drilling, tapping, deburring, cleaning and assembly are defined
Finish	[ ] Process, color/gloss/texture, samples, masking, contacts and final dimensions are defined
Inspection	[ ] Datum, method, support condition, sampling, reports and appearance approval are agreed
Logistics	[ ] Packaging, protection, labeling, shipping length and handling restrictions are stated

SEND YOUR RFQ Submit the model, drawings and application requirements through the BAOSONG contact page.

CHANNEL	CLICK TO CONTACT
Website	baosongprecision.com
Extrusion service	aluminum extrusion services
Engineering	engineering support
RFQ	baosongprecision.com/contact-us/
Email	info@aagintr.com
Telephone	+86-757 8556 3891
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Contact details verified against the BAOSONG website on 11 September 2026.

APPENDIX References and Use Limitations

Use the contract-specified edition of every standard and validate the actual profile with the selected supplier.

SOURCE	REFERENCE	LINK
Aluminum Extruders Council	Extrusion Design Tips	Open source
Aluminum Extruders Council	Design Resources and Aluminum Extrusion Manual	Open source
The Aluminum Association	ANSI H35.2/H35.2M - Dimensional Tolerances for Aluminum Mill Products, 2024	Open source
The Aluminum Association	Aluminum Standards and Data 2024	Open source
The Aluminum Association	Standards and alloy/temper registration resources	Open source
ASME	Y14.5-2018 (R2024) Dimensioning and Tolerancing	Open source
NIST	Uncertainty and Dimensional Calibrations	Open source
BAOSONG	Aluminum Extrusion Services	Open source
BAOSONG	Aluminum Extrusion Tolerances for Designers	Open source

Use limitation

This guide provides design-review questions and qualitative engineering relationships. It does not define universal minimum wall thickness, tongue ratio, press capacity, tolerance, mechanical property, finish capability, die life, lead time or price. The approved drawing, purchase requirements, governing standards and validated supplier process take precedence.

Internal BAOSONG resources

Continue with custom extrusion services, extrusion machining, surface finishing, quality and inspection or contact BAOSONG for a project-specific review.

BAOSONG

For a profile-level manufacturability discussion, use BAOSONG Engineering Support or send the controlled files and production requirements.