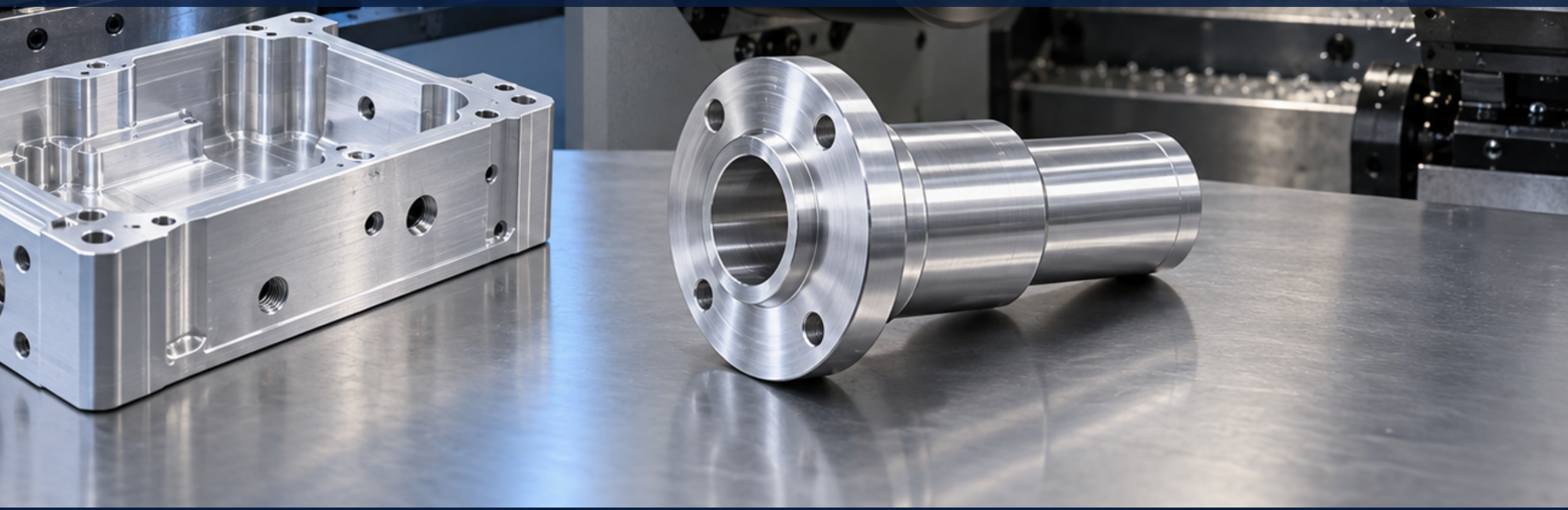
DESIGN FOR MANUFACTURING

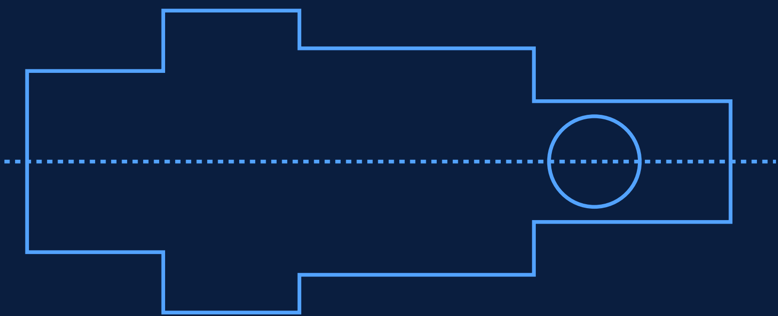
CNC TURNING GUIDE

DIAMETERS, THREADS & CONCENTRIC FEATURES



A feature-level DFM handbook for precision aluminum turned parts

Datum axes | OD/ID fits | Grooves | Thread runout | Radial and axial runout



Prepared by BAOSONG

baosongprecision.com

Version 1.0 | September 2026 | Metric units

Conceptual manufacturing image - not a capability statement

00 Design Logic and Contents

Use this guide for shafts, sleeves, flanges, bushings, threaded adapters and mill-turn components.

START WITH THE AXIS

Define the functional rotation or assembly axis first. Then decide which diameters, faces and threads must be produced or inspected from that axis in one setup.

Three design layers

LAYER	PRIMARY QUESTION	COMMON FAILURE
Size and fit	What diameter or thread creates the fit, seal or clearance?	Blanket tight limits without a functional tolerance stack
Axial relationship	Which shoulder or face locates the assembly?	Length chains across setups with no functional datum face
Coaxial / rotational relationship	What must rotate or assemble about a common datum axis?	Using the word concentric without selecting the correct GD&T; control

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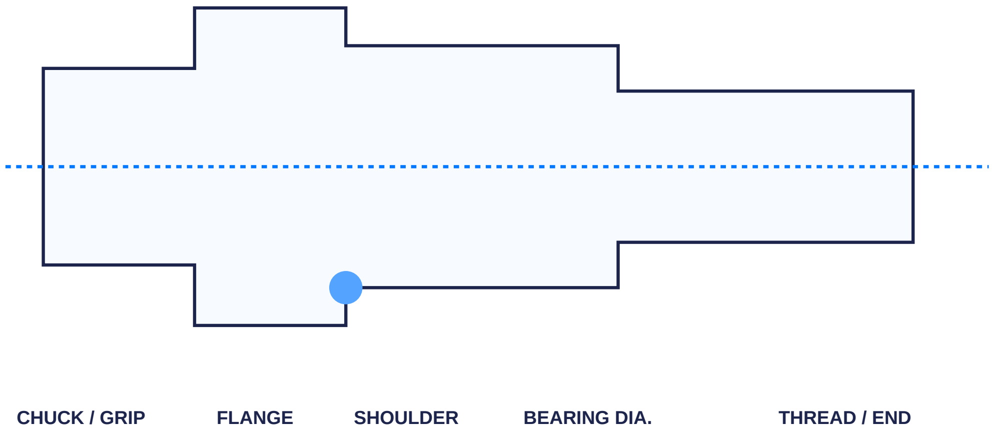
01 Turned Feature Anatomy

A turned part is a sequence of coaxial diameters, axial faces, transitions, grooves and end features.



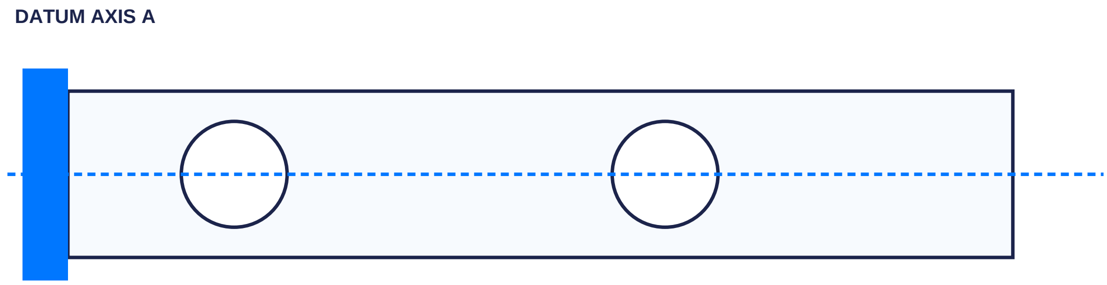
1.1 Give every feature a purpose

FEATURE	FUNCTIONAL ROLE	DFM QUESTION
Grip diameter	Workholding and process location	Can it remain available until the critical features are complete?
Bearing or seal diameter	Fit, motion or sealing	What size, form, texture and axis relationship protect function?
Shoulder face	Axial location or thrust reaction	Which datum face controls the length stack and runout?
Groove / relief	Seal, retaining ring, tool runout or assembly clearance	Is it standard, accessible and free of burr ambiguity?
Thread	Fastening, adjustment or fluid connection	Which standard, class, lead, runout and gauging apply?
Cross hole / milled flat	Secondary orientation or connection	Can it be made in the same setup or needs a controlled transfer?

SERVICE LINK See BAOSONG aluminum CNC turning for a drawing-specific route review.

02 Functional Datum Axis and Setup Logic

The spindle axis is a process axis. The drawing datum axis should represent assembly or rotation function.



Locate and orient functional diameters from the axis that represents assembly and rotation.

2.1 Establish the datum sequence

- Choose a stable cylindrical datum feature that represents the installed bearing, pilot, bore or shaft interface.
- Select an axial datum face that represents assembly seating or thrust location.
- Use a clocking datum only when flats, ports, bolt patterns or keys require angular orientation.
- Keep function-related diameters and shoulders in one setup where practical to reduce datum transfer.

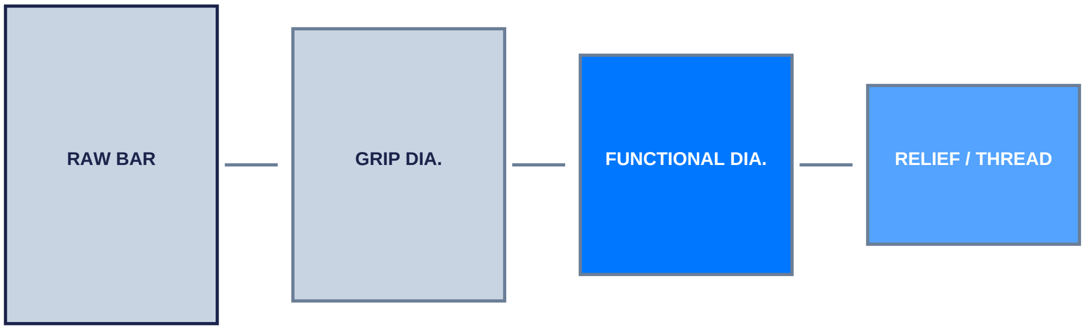
2.2 Process-axis traps

TRAP	WHY IT FAILS	BETTER APPROACH
Datum is raw bar OD	Stock runout does not represent the finished assembly	Create a controlled finished datum feature
Critical OD and ID finished in separate grips	Rechucking adds relationship error	Finish from one grip or use a qualified transfer feature
Length stack references both ends independently	Cutoff and second operation compound variation	Reference the functional seating face and close the stack deliberately
Cross holes lack clocking datum	Angular relationship is implicit	Add a clocking datum or basic angle from a functional feature

KEY DISTINCTION A part may run true in the chuck and still fail the released drawing if the process axis does not represent the specified functional datum axis.

03 Diameter Hierarchy and Fits

Reduce the profile to functional diameters, process diameters and clearance diameters.



Each diameter should exist for gripping, function, clearance, sealing, bearing, thread or process relief.

3.1 Diameter requirements

DIAMETER TYPE	CONTROL INPUTS	INSPECTION QUESTION
Clearance OD / ID	Envelope and minimum gap	Is limit size enough, or does location also matter?
Slip / location fit	Mating size, temperature and assembly method	Which standards and actual mating data define the fit?
Press / interference fit	Material, wall thickness, insertion and service temperature	Will the aluminum hub expand, yield or relax?
Bearing seat	Fit class, shoulder, runout and texture	What datum axis and operating speed drive acceptance?
Seal land	Diameter, texture, lead and runout	Does the process leave spiral lead or a damaging transition?
Thread major / minor / pitch diameter	Standard, class and coating state	Which gauge or measurement method proves acceptance?

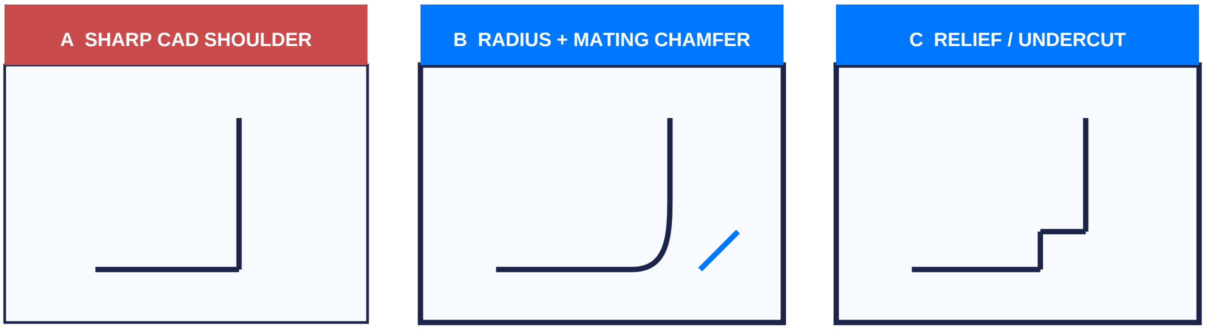
3.2 Avoid isolated nominal sizes

- Define the complete mating system: size, tolerance, finish, temperature, coating and assembly force.
- Do not tighten every step diameter because one bearing seat is precise.
- Leave a practical stock difference between adjacent diameters so tools can form the transition and inspect the result.

TOLERANCE LINK Use BAOSONG's aluminum CNC tolerance guide to connect diameter, datum and inspection decisions.

04 Shoulders, Fillets and Chamfers

A shoulder is both an axial locating feature and a tool-access transition.



Choose the transition from load path, seating face, tool access and mating-part geometry.

4.1 Select the transition from function

SOLUTION	USE WHEN	CHECK
Generous fillet	Stress flow and tool life matter; mating part clears it	Mating chamfer, bearing corner radius and seating width
Small controlled radius	Assembly needs a near-square shoulder	Tool nose radius, finish path and fatigue sensitivity
Relief / undercut	A mating face must seat fully or tool needs runout	Standard groove form, local stress and burr access
Chamfer	Lead-in, edge protection or mating clearance	Angle, width, functional contact and inspection
Taper	Self-location, sealing or release	Angle basis, contact length, gauge and axial sensitivity

4.2 Axial face controls

- Control the seating face from the functional axial datum, not from an arbitrary stock end.
- Use axial runout only when face wobble during rotation matters; flatness and perpendicularity answer different questions.
- Protect effective shoulder width when adding fillets, undercuts or chamfers.

ASSEMBLY CHECK

Model the mating component corner. Many shoulder disputes come from specifying a sharp seat without defining the mating chamfer or radius.

05 Grooves, Undercuts and Parting Relief

Groove width, depth, corner radii, access direction and bottom form determine tool choice and chip control.

5.1 Groove feature map

FEATURE	DESIGN INPUT	COMMON RISK
Retaining-ring groove	Applicable ring standard, sidewall and root requirements	Custom geometry or burr prevents ring seating
O-ring / seal groove	Seal standard, squeeze, finish and edge condition	Wrong root radius, spiral lead or sharp insertion edge
Tool runout relief	Thread/shoulder tool path and effective length	Relief omitted or too narrow for the actual tool
Face groove	Radial position, width, depth and entry	Toolholder clearance and chip packing
Internal groove	Bore diameter, depth and visibility	Bar reach, insert width and inspection access
Parting location	Grip length, cutoff path and remnant	Pip, burr, distortion and unstable final support

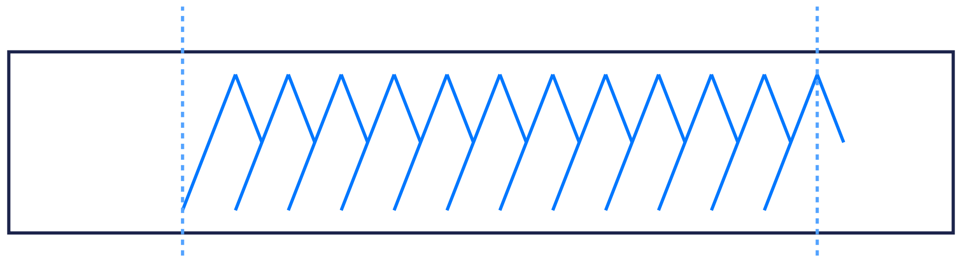
5.2 Prefer controlled standard geometry

- Use the applicable seal, ring or thread relief standard rather than a visually similar custom groove.
- Dimension width, depth/diameter, location, corner condition and surface requirement explicitly.
- For deep or internal grooves, confirm bar and holder clearance plus chip evacuation before release.
- If a groove is only tool relief, state that function so the supplier can propose an equivalent manufacturable form.

BURR PLAN	Specify which groove edges are broken, which remain functional, and how internal burrs are inspected.

06 External Threads

A complete external-thread requirement includes standard, size, pitch, class, length, lead, runout, crest condition and final finish state.



Define full-thread length separately from overall feature length and tool runout space.

6.1 Thread definition

INPUT	WHAT TO STATE	WHY IT MATTERS
Standard and designation	For example, governing ISO metric or ASME inch thread standard	Defines profile, series and interpretation
Pitch and hand	Coarse/fine pitch and right/left hand	Affects strength, adjustment, tooling and assembly
Tolerance class	External class and coating/finish condition	Defines pitch-diameter acceptance and allowance
Full-thread length	Usable thread, not only overall turned length	Separates function from lead and runout
End lead	Chamfer or controlled start	Prevents cross-threading and protects first full thread
Runout / relief	Permitted incomplete thread and tool exit	Prevents conflict with a mating shoulder
Gauge / inspection	Specified method where contract requires it	Aligns acceptance with thread function

6.2 Design choices

- Prefer standard diameters and pitches. Use fine pitch only when wall, adjustment, preload or axial motion justifies it.
- Provide a lead chamfer that supports assembly without reducing the required full-thread engagement.
- Keep the thread away from abrupt shoulders unless a standard relief provides tool exit and mating clearance.

07 Internal Threads and Blind Features

Internal turning combines bore access, bar reach, chip evacuation and incomplete-thread allowance.

7.1 Blind-thread stack

ZONE	FUNCTION	DESIGN ACTION
Entry chamfer	Guide the fastener and protect the first thread	Dimension chamfer without consuming required engagement
Full thread	Carry load or provide adjustment	Specify usable length from the functional face
Incomplete thread / runout	Tool lead and exit region	Do not count it as full engagement
Bottom clearance	Tool tip, chips and drill/boring geometry	Add depth beyond full thread and distinguish total depth
Finish allowance	Anodize or coating changes the thread	Define masking, allowance, chasing or post-finish gauge

7.2 Internal-thread DFM questions

- Can the tool or gauge enter through the bore without holder interference?
- Is the bore deep enough for full thread plus lead, runout and chip space?
- Can chips escape, or is a different threading method preferable?
- Does the wall around the thread support the installation and service load?
- Is the feature actually better as a standard insert, nut, stud or threaded boss?

7.3 Thread engagement

Do not use a universal engagement multiplier as proof of joint strength. Validate material, class, shear area, preload, fatigue, temperature, repeated service and any thread insert. The joint calculation and governing standard control.

STANDARD NOTE	ISO 261 defines the general plan for ISO metric threads; basic dimensions and tolerances are handled by related ISO thread standards. Use the contract-specified editions.

08 Thread Runout, Lead and Inspection

Many thread problems occur outside the nominal full-thread region.

8.1 Protect the first and last full threads

AREA	DESIGN RISK	CONTROL
Start / lead	Sharp edge, cross-threading or short usable length	Controlled chamfer, clean crest and protected edge
Full thread	Unclear engagement datum	Dimension from the functional seating face
Runout	Mating part stops before seating	Provide relief or verified noninterference zone
Shoulder	Tool cannot exit without touching the face	Separate shoulder and thread finishing strategy
Coated thread	Pitch diameter changes or gauge fails	Specify finished-state class, masking or post-process action

8.2 Gauge strategy

- Go/no-go gauges verify defined functional limits but do not report every geometric cause of failure.
- Three-wire, pitch-diameter, optical or CMM methods may support development or diagnosis when required.
- State whether acceptance occurs before or after anodizing, conversion coating or other treatment.
- Protect gauging surfaces from burrs, nicks, embedded chips and handling damage.

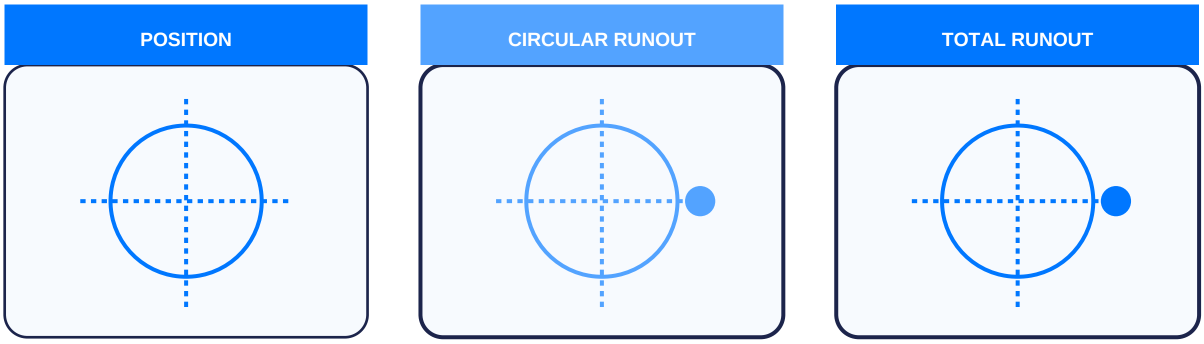
8.3 Cutting data

Thread-turning infeed strategy, pass count, insert geometry and cutting data are tool-, pitch-, material-, machine- and setup-specific. Start from the selected tooling supplier's application data, then validate on the actual process.

SOURCE LINK	Sandvik Coromant's Threading Application Guide provides thread-turning and thread-milling application context.

09 Coaxial Features and GD&T; Choices

Translate the word concentric into the actual functional requirement before selecting a control.



Select the control from assembly, rotation, surface form and inspection - not from the word 'concentric'.

9.1 What does the assembly need?

FUNCTION	LIKELY CONTROL FAMILY	WHY
Mating cylindrical feature must assemble on a datum axis	Position of the feature axis	Directly expresses axis location; modifiers may support assembly logic when allowed
Surface must run true at each circular section	Circular runout	Combines radial surface variation during one revolution at each checked section
Entire rotating surface must run true across length	Total runout	Adds axial sampling and stronger composite surface control
Single surface must be round without a datum	Circularity	Controls form at circular cross-sections, not relationship to another axis
Whole cylindrical surface needs form control without a datum	Cylindricity	Controls the full cylinder form, not assembly-axis location

9.2 ASME edition warning

ASME Y14.5-2018 no longer supports the former concentricity symbol. Legacy drawings and ISO-based drawings may use different terminology or controls. Always state the governing standard and edition, and do not translate a legacy callout by name alone.

PRACTICAL RULE	Use position when assembly of axes is the main concern. Use runout when rotating surface behavior is the main concern. Confirm the inspection method before release.

10 Runout, Circularity and Cylindricity

These controls overlap in appearance but protect different aspects of function.

CONTROL	DATUM?	WHAT IT EMPHASIZES	INSPECTION IMPLICATION
Circularity	No	Form of each circular element	Requires appropriate rotational or form measurement; size alone is not proof
Cylindricity	No	Form of the entire cylindrical surface	More comprehensive form data over length
Circular runout	Yes	Variation of a surface section relative to datum axis during rotation	Datum simulation and indicator/CMM strategy matter
Total runout	Yes	Composite variation over the whole controlled surface	Requires sampling along the surface while referenced to datum axis
Position of axis	Yes	Location/orientation of derived axis	Feature extraction and datum establishment must follow the governing standard

10.1 Avoid redundant stacks

- Do not add circularity, cylindricity, runout, position and a very tight size tolerance to the same diameter without a functional reason.
- A bearing seat may need size, texture and runout; an ordinary clearance diameter may need only size.
- Face runout, face flatness and perpendicularity are not interchangeable. Select from axial seating and rotational behavior.
- Define the datum feature order and any material-boundary modifiers according to the governing standard.

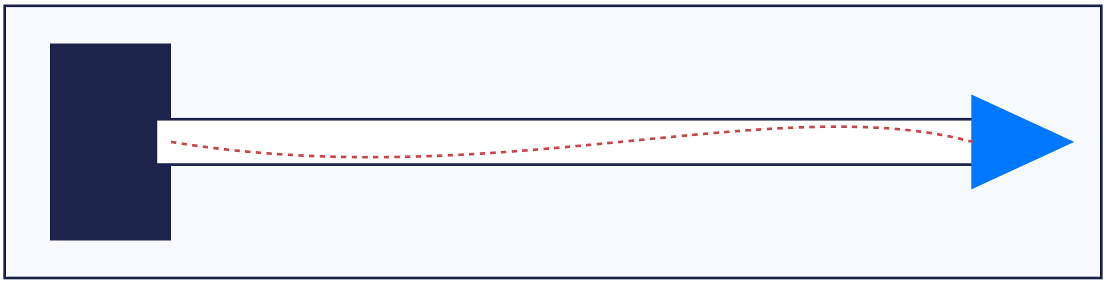
10.2 Dynamic behavior

Geometric conformance does not automatically prove balance, vibration, bearing life or high-speed performance. Rotating assemblies may also require mass-property control, component balance, assembly procedure and operating validation.

DRAWING REVIEW	A tolerance that cannot be explained in terms of fit, rotation, seal, load or inspection is a candidate for clarification before quotation.

11 Slender Shafts and Deflection

Long unsupported features are sensitive to cutting force, workholding, tool pressure and residual stress.



Slenderness, overhang, cutting force, support and sequence govern deflection and chatter.

11.1 Slenderness is a system property

INPUT	RISK	POSSIBLE RESPONSE
High length-to-diameter ratio	Bending, chatter and taper	Add tailstock/center support, steady rest, intermediate support or redesign
Long stick-out from chuck	Low workpiece stiffness	Reduce overhang, change sequence or use bar support
Thin tube wall	Ovalization and jaw distortion	Use collet, soft jaws, plug/mandrel support or controlled grip force
Interrupted cut / flats	Cyclic force and vibration	Sequence secondary features, select robust tooling and support
Heavy asymmetric stock removal	Residual-stress movement	Balance roughing, stabilize and re-establish datums

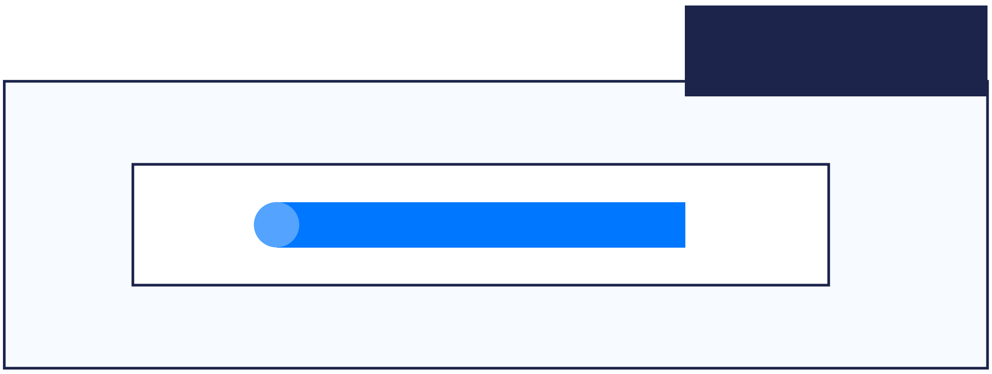
11.2 Design levers

- Increase local diameter where mass and envelope allow, especially near load and grip transitions.
- Add a center feature or sacrificial support extension when appropriate, then define its removal.
- Avoid locating a critical bearing or seal diameter at the least-supported free end if the architecture can change.
- Separate roughing and low-force finishing when springback or thermal movement affects CTQs.

FREE-STATE CHECK	Specify whether straightness, runout and diameter are accepted free, between centers, or under a defined assembly restraint.

12 Bores and ID Tool Access

Internal diameters are governed by entry diameter, depth, boring-bar overhang, chip path and inspection reach.



ID depth, bore diameter and bar overhang must be reviewed together with chip and coolant access.

12.1 Bore feature decisions

FEATURE	ACCESS QUESTION	DESIGN RESPONSE
Deep straight bore	Can a stiff bar reach the full length and evacuate chips?	Increase entry diameter, shorten depth or provide access from both ends
Stepped bore	Can the larger bar pass through preceding diameters?	Order steps from access side or split operations deliberately
Blind bore	Is bottom form compatible with the tool?	Allow realistic corner/bottom geometry and chip space
Internal shoulder	Can the insert form the face and exit?	Add relief, access diameter or separate tool path
Internal groove / thread	Does the holder clear and can it be gauged?	Increase bore, move feature toward opening or specify special inspection
Opposed bores	How are axes related across setups?	Use a common datum and a qualified transfer or single-setup process

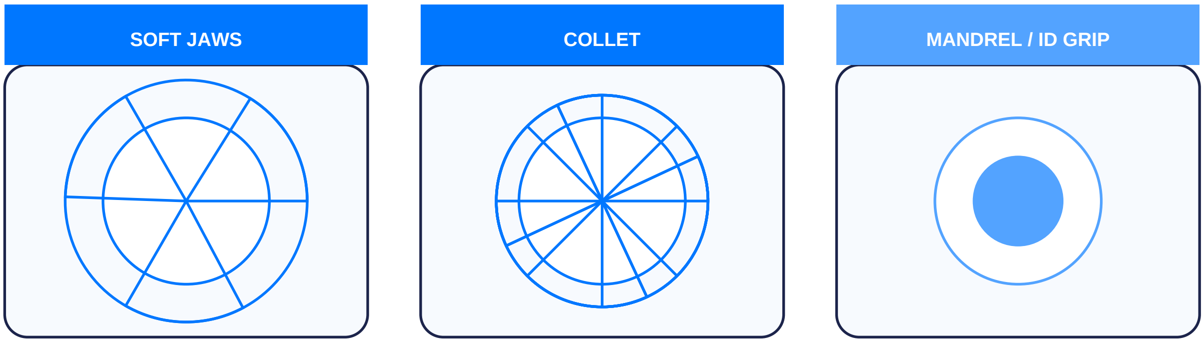
12.2 Bore finish and lead

A seal or bearing bore may need size, form, texture and runout control. Specify the functional combination, and consider whether the turning process may leave helical lead that matters to the seal. Do not use Ra alone as proof of sealing performance.

MEASUREMENT ACCESS	Confirm that the bore gauge, air plug, CMM stylus or functional gauge can reach the feature from the specified datum setup.

13 Workholding, Stock and Setup Transfer

Workholding should establish the process datum, transmit torque and avoid damage or distortion.



Grip a stable feature that represents the process datum without damaging or distorting the functional surface.

METHOD	STRENGTH	RISK TO CONTROL
Three-jaw chuck / soft jaws	Flexible, strong grip and profile support	Jaw runout, grip marks and distortion
Collet	Distributed grip and good repeatability on suitable stock	Range, bar variation and limited irregular profiles
ID mandrel / expanding arbor	Preserves OD access and references bore	Bore readiness, expansion distortion and axial seating
Between centers	Supports long shafts about center features	Center quality, drive torque and final removal
Tailstock / steady rest	Reduces unsupported length	Support force, wear and access to features
Second-operation jaws	Re-grips a finished feature	Datum transfer, jaw cleanliness and protected surface

13.1 Stock and cutoff planning

- Provide enough grip length and cutoff allowance without forcing excessive material waste.
- For bar-fed work, confirm stock diameter, straightness, surface and feeder/support constraints.
- If the last feature is created after cutoff, define how the part is re-gripped and which datum is preserved.
- Use mill-turn or live-tool operations when they reduce datum transfer for flats, holes, slots or bolt patterns.

PROCESS CHOICE Compare CNC milling and CNC turning when the part combines rotational and prismatic features.

14 Surface Finish, Burrs and Parting

The final edge and surface condition must match the fit, seal, motion and handling function.

14.1 Surface requirements by function

SURFACE	CONTROL SET	COMMON MISTAKE
Bearing seat	Diameter, fit, texture, shoulder and runout	Applying the same fine finish to unrelated diameters
Dynamic seal land	Diameter, lead, texture, runout and edge	Using Ra alone without lead or transition control
Static O-ring interface	Groove geometry, finish and edge condition	Burr or tool marks across sealing path
Sliding guide	Size, straightness, texture and lubrication	Ignoring coating and temperature effects
Cosmetic turned face	Lay, appearance sample, handling and finish process	Treating tool marks as a purely numerical Ra issue
Cutoff end	Length, squareness, pip and burr	No second-operation allowance or visible-edge rule

14.2 Edge classification

- Identify assembly leads, seal-protection edges, thread starts, retaining-ring groove edges and handling edges separately.
- Do not apply one generic edge break to a sharp functional land and a hand-contact edge.
- Internal burrs at cross holes, grooves or thread exits require a defined method and acceptance condition.
- Parting-off may leave a pip or burr; define whether a second operation removes it and which face controls final length.

FINISH LINK Review BAOSONG surface finishing before assigning post-treatment size or cosmetic requirements.

15 Inspection Strategy

Tie every critical feature to a datum simulation, instrument, final state and decision rule.

15.1 Measurement map

CHARACTERISTIC	POSSIBLE METHOD	DEFINE BEFORE RELEASE
Outside diameter	Micrometer, snap gauge or optical system	Location along length, temperature and coating state
Inside diameter	Bore gauge, air gauge or CMM	Depth, orientation, master and access
Thread	Go/no-go gauge or specified analytical method	Standard, class, finished state and gauge practice
Circular / total runout	Indicator, roundness system or CMM	Datum simulation, rotation, sections and support
Circularity / cylindricity	Form measurement or qualified CMM strategy	Filtering, sampling and evaluation standard
Axial shoulder location	Height/length gauge, CMM or functional gauge	Datum face, contact zone and burr control
Surface texture	Profilometer or defined comparison method	Parameter, cutoff/filter, direction and location

15.2 Inspection can move the part

- Slender shafts and thin tubes may bend under support, probe or clamping force.
- Temperature differences can materially affect aluminum diameter at tight tolerances.
- A long stylus or bore gauge can introduce access and alignment uncertainty.
- Measurement near a specification limit needs an agreed decision rule and uncertainty awareness.

QUALITY LINK BAOSONG's quality overview lists useful project inputs for inspection and documentation planning.

16 Cost and DFM Redesign Example

The best value change removes a setup, special tool or difficult measurement while preserving the functional axis and interface.

16.1 Cost drivers

DESIGN CHOICE	COST EFFECT	LOWER-RISK ALTERNATIVE
Many unrelated precision diameters	Multiple finish passes and inspection	Identify only bearing, seal and pilot CTQs
Thread ends at a shoulder	Special relief and gauging dispute	Add standard runout relief or move the shoulder
Deep small ID groove	Long special bar and hard inspection	Move groove toward entry or redesign retention
OD and ID relationship across two grips	Special jaws and datum transfer	Finish in one setup or add a qualified transfer feature
Blanket total runout	Full-surface inspection and rejection sensitivity	Apply circular or total runout only to rotating functional surfaces
Long thin shaft with no center support	Slow low-force cutting and chatter risk	Add temporary center feature or increase local diameter

16.2 Redesign example

ORIGINAL	RISK CHAIN	REVISED DEFINITION
Bearing OD, seal OD and internal bore finished in different setups	Rechucking drives axis relationship and runout	Finish all three from one primary grip; use datum A on the bearing pilot
M20 thread runs into seating shoulder	Incomplete thread blocks seating	Add standard relief and define full-thread length from the face
Total runout 0.02 on every OD	Unnecessary finishing and inspection	Apply total runout only to seal land; position the assembly pilot axis
180 mm shaft at 12 mm diameter with no center	Deflection and chatter at free end	Add sacrificial center extension and low-force final pass
Anodize covers bearing seat and thread	Fit and gauge change after finish	Mask bearing seat and define finished-state thread acceptance

FIRST ARTICLE Record diameter, runout, thread gauge, free-state straightness and the effect of support/removal. Use the evidence to set production offsets and sampling.

17 Release Checklist and Contact BAOSONG

Complete the feature map before RFQ or drawing release.

MODULE	RELEASE CONDITION
Axis	[ ] Functional datum axis and axial seating face are defined
Diameters	[ ] Each tight OD/ID protects a documented fit, seal, bearing or pilot
Transitions	[ ] Fillets, chamfers and undercuts match the mating component and tool path
Grooves	[ ] Standard, width, depth, location, radii and burr condition are explicit
Threads	[ ] Standard, pitch, class, hand, full length, lead, runout and finished state are complete
Coaxiality	[ ] Position/runout/form control matches function and governing GD&T; edition
Slenderness	[ ] Overhang, support and free-state acceptance have been reviewed
Bores	[ ] ID entry, bar reach, holder, chips and gauge access are feasible
Workholding	[ ] Grip feature remains available and does not damage or distort the part
Inspection	[ ] Datum simulation, method, temperature, state and sampling are defined

SEND YOUR RFQ

Submit the 3D model, 2D drawing, material, quantities, CTQs, finish and inspection scope through the BAOSONG contact page.

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Contact details verified against the BAOSONG website on 11 September 2026.

APPENDIX References

Use the contract-specified edition of every standard and validate tooling guidance on the actual process.

SOURCE	REFERENCE	LINK
ISO	ISO 261:1998 - ISO general purpose metric screw threads	Open source
ISO	ISO 965-2:2024 - limits for general purpose metric threads	Open source
ASME	Y14.5-2018 (R2024) Dimensioning and Tolerancing	Open source
Sandvik Coromant	Threading Application Guide	Open source
Sandvik Coromant	Parting and Grooving Tools 2026	Open source
Haas Automation	Tip of the Day - speeds, feeds and lathe resources	Open source
NIST	Uncertainty and Dimensional Calibrations	Open source
BAOSONG	Aluminum CNC Turning	Open source

Use limitation

This guide provides design-review questions and qualitative engineering relationships. It does not define universal diameter tolerance, fit, thread engagement, groove geometry, runout capability, cutting data or inspection uncertainty. Approved drawings, contracts, governing standards and validated supplier process documents take precedence.

BAOSONG	For a feature-level manufacturability discussion, use BAOSONG Engineering Support or send the drawing and application requirements.