

PRECIMETAL CAST PVT. LTD.

We Cast Your Needs

DFM Guidelines

Design for Manufacturing · Investment Casting Reference

DOC. NO. PRS- MKT- 04

REV. NO. 01

REV. DATE AUGUST 2026

01 INTRODUCTION

Investment casting delivers near-net-shape components with fine detail, tight tolerances, and complex internal geometries that would be impossible or prohibitively expensive to machine from stock. Getting the best out of the process, however, starts at the design stage — not on the shop floor.

This guide summarises design-for-manufacturing principles that make investment castings faster, cheaper, and more reliable to produce. Some are universal to the process; others are specific to what Precimetal's equipment, wax chemistry, and shell systems support in practice.

Where a value is given as a "typical range for investment casting", treat it as a reasonable starting point for design. For any part where a dimension approaches those limits — or where the application is critical — please contact our engineering team early. Early engineering consultation can significantly reduce tooling and machining costs by identifying manufacturability improvements before the design is released for production.

1.1 How to Use This Document

- Sections 2–3 cover the fixed envelope Precimetal manufactures within — the specifications you can design against directly.
- Sections 4–11 cover investment casting design principles — geometry rules that apply broadly across the process.
- Sections 12–13 cover cost drivers, file handoff, and how to engage our engineering team on a specific part.
- Callout boxes marked “Confirm with Engineering” flag values that depend on your specific geometry and material — send us the part model early and we’ll return a definitive answer.

02 PRECIMETAL'S MANUFACTURING ENVELOPE

The following envelope is what Precimetal currently manufactures across in routine production. Requirements outside these ranges are not automatically excluded. Our engineering team can evaluate and qualify project-specific limits based on geometry, alloy, volume, and process requirements.

PARAMETER	PRECIMETAL ENVELOPE
Weight Range	20 grams to 30 kilograms
Maximum Part Envelope	400 × 400 × 400 mm
Casting Process	Lost-wax investment casting — water-soluble core and ceramic core variants
Alloy Families	Carbon steel, alloy steel, stainless (austenitic, martensitic, duplex, ferritic), tool steel, precipitation-hardening
Secondary Processes	CNC machining, heat treatment, non-destructive testing, surface finishing, sub-assembly
Annual Production Capacity	720 metric tonnes (60 MT per month)

CONFIRM WITH ENGINEERING

Parts significantly outside this envelope — particularly on the upper weight or size limits — are still worth discussing. We regularly adapt tooling and process to accommodate one-off geometries when the volume and application justify it.

03 TOLERANCE & SURFACE FINISH

Precimetal supports demanding casting tolerance grades in accordance with applicable industry standards. Select the appropriate tolerance class based on functional requirements; unnecessarily tight tolerances can increase machining and manufacturing costs.

3.1 Standard Casting Tolerance

STANDARD	PRECIMETAL CAPABILITY
IS 11166	Class 1 & Class 2
VDG P690	D3 and D2

3.2 Surface Finish

SURFACE TYPE	TYPICAL RA (MM)
As-Cast	$Ra \leq 3.2 \mu m$
Machined	$Ra \leq 0.4 \mu m$ achievable, subject to material, geometry, and machining process
Special finishes	Shot blasting · Tumbling/polishing · Electropolishing — application-specific

For a full breakdown of tolerance bands by nominal dimension across IS 1166 and VDG P690, see our published tolerance envelope tables (available on request).

04 WALL THICKNESS

Wall thickness is the single most consequential parameter in investment casting. Too thin, and the ceramic shell may not fill uniformly; too thick, and shrinkage porosity risks arise during solidification. Uniform thickness across the part is more important than absolute minimum thickness.

4.1 Typical Wall Thickness Ranges

WALL PARAMETER	TYPICAL FOR IC
Minimum wall (small components)	1.5 mm typical for most alloys
Minimum wall (specialised sections)	0.75 mm achievable with process qualification
Preferred wall for consistent quality	3.0 – 6.0 mm

4.2 Design Principles

- Aim for uniform wall thickness. Abrupt changes cause differential cooling, distortion, and internal stress.
- Where a thickness transition is unavoidable, use a gradual taper (3:1 blend ratio or gentler) rather than a step change.
- Isolated thick sections (bosses, hubs) should be blended into surrounding walls with generous fillets, not connected by narrow necks.
- Consider hollowing very thick sections with cored passages — investment casting supports this well and it improves both weight and metallurgy.

CONFIRM WITH ENGINEERING

Minimum wall thickness depends on section length, alloy fluidity, and adjacent geometry. A 0.75 mm wall may be achievable in a small localised area on a well-designed part, while 2.0 mm may be the practical minimum on a long thin flange. Share your part model early; we'll return a specific answer.

05 DRAFT ANGLES

Investment casting is one of the few metal-forming processes where zero-draft geometry is routinely achievable. The wax pattern is produced in a hard tool, but the ceramic shell is broken away after solidification — so vertical walls, straight bores, and even mild undercuts are all in scope.

5.1 Typical Draft Angle Guidance

SURFACE TYPE	RECOMMENDED DRAFT
Standard vertical surfaces	0° draft achievable (major IC advantage)
Deep pockets or cavities	0.5° – 1° recommended for reliable wax pattern release
Very deep or narrow cavities	Consider a soluble or ceramic core rather than draft
Textured surfaces	1° minimum draft to prevent wax tearing

5.2 When Draft Matters

- Long parallel walls in a pattern die: mild draft (0.5°) makes wax release cleaner and extends tool life.
- Adding a small draft angle generally has minimal impact on casting cost and can improve wax pattern release and tooling life. If your design tolerates it, add it.
- True zero-draft comes at slightly higher tooling and process complexity; specify it only where the application requires vertical walls.

06 FILLETS, RADII & CORNERS

Sharp internal corners are stress concentrators, hot-spot risks for cooling, and a leading source of casting defects. Generous fillets improve metal flow, reduce residual stress, extend fatigue life, and simplify pattern manufacture.

6.1 Typical Fillet Guidance

FEATURE	TYPICAL VALUE
Internal fillet radius (minimum)	0.5 mm — avoid true sharp corners entirely
Internal fillet radius (preferred)	3.0 mm or 0.5× wall thickness, whichever is larger
External corner radius (minimum)	0.5 mm — improves ceramic shell integrity
Rib-to-wall junction fillet	0.5× rib thickness
Boss-to-wall junction fillet	0.5× wall thickness

6.2 Design Principles

- Generous fillets generally have minimal impact on tooling cost and can improve metal flow, reduce local stress concentrations, and support more consistent casting quality.
- External corners can carry a smaller radius but should never be truly sharp — they weaken the ceramic shell locally.
- For stress-critical junctions (rib roots, boss junctions), oversize the fillet rather than undersize it.

07 HOLES, BOSSES & CORED FEATURES

Investment casting can produce holes as cast (with cores) or leave stock for machining. Cast-in holes save material and machining time but have depth limits; machined holes offer full precision but add cost. Choose based on the diameter, depth, and precision required.

7.1 As-Cast Hole Guidance

HOLE PARAMETER	TYPICAL FOR IC
Minimum as-cast hole diameter	8.0 mm typical ($\pm$ casting tolerance)
Through-hole depth-to-diameter ratio	Up to 3:1 with a straight core
Blind-hole depth-to-diameter ratio	Up to 2:1 with a straight core
Deeper holes	Consider a tapered core (up to 6:1) or a soluble core
As-cast hole tolerance	General casting tolerance applies; specify machining for fits

7.2 Bosses & Threaded Features

- Boss thickness: aim for $0.75\times$ the adjacent wall thickness. Thicker bosses risk isolated hot spots.
- Boss diameter: at least $2\times$ the hole diameter, with adequate wall around the hole for machining if required.
- Threads: never cast threads directly — tap or machine them post-casting. Cast a starter hole undersized to the tap drill.
- For blind tapped holes, provide a small relief at the bottom for chip clearance.

08 UNDERCUTS & INTERNAL GEOMETRY

One of investment casting's biggest advantages is the ability to produce complex internal geometry that would be impossible or prohibitively expensive to machine. Precimetal's in-house core capability makes this particularly cost-effective.

8.1 Core Options at Precimetal

CORE TYPE	APPLICATION
Ceramic Core	Pre-formed ceramic; supports high-temperature service and fine internal detail
Water-Soluble Core	In-house; removed post-casting with water — ideal for complex internal passages
Quick-Set Gel	Proprietary; supports closed impellers with 3D vein geometries

8.2 Design Principles

- Complex internal passages, curved bores, and cross-drilled geometries that would require multi-axis machining can often be cast directly — significantly reducing cost.
- Undercuts on external surfaces are viable within limits. The ceramic shell is broken away, so mild undercuts release naturally.
- Large or deep undercuts may require multi-piece tooling, which raises tooling cost but often still beats the machining alternative.

DESIGN ADVANTAGE

Precimetal's in-house water-soluble core and quick-set gel capability is particularly valuable for automotive components with complex fluid passages, closed impellers with 3D vein geometries, and other parts that competitors cannot cast without multi-piece tooling or extensive machining.

09 RIBS, WEBS & SURFACE FEATURES

9.1 Ribs and Webs

Ribs add stiffness without adding much weight. In investment casting they are straightforward to produce, but their thickness needs to be balanced against the wall they attach to.

RIB PARAMETER	TYPICAL VALUE
Rib thickness	0.75× adjacent wall thickness (never thicker than the wall)
Rib height	Up to 4 × rib thickness
Rib spacing	Minimum 3 × rib thickness apart
Rib fillet radius	0.5 × rib thickness at the wall junction

9.2 Surface Text, Logos & Identification

TEXT PARAMETER	TYPICAL MINIMUM
Raised lettering — stroke width	0.5 mm minimum
Raised lettering — height	0.3 mm minimum above surface
Depressed lettering — stroke width	0.5 mm minimum
Depressed lettering — depth	0.3 mm minimum below surface
Character height	3.0 mm minimum for reliable legibility
Logo detail	Simplify fine detail; sans-serif fonts cast most reliably

Raised lettering is generally more reliable than depressed — the wax and shell fill more consistently around a raised feature. Depressed features are viable but may need slightly generous depth.

10 MATERIAL SELECTION

Alloy choice drives both mechanical performance and manufacturability. Different alloys have different fluidity, shrinkage rates, and heat-treatment responses — all of which affect what geometry is achievable.

10.1 General Alloy Considerations

ALLOY FAMILY	DESIGN CONSIDERATION
Carbon steel (WCA, WCB, WCC)	Good fluidity and weldability; suitable for general engineering applications
Stainless (CF8, CF8M, 316-type)	Corrosion resistance; slightly higher shrinkage than carbon steel
Duplex / Super Duplex	Chloride and pitting resistance; requires careful heat treatment
Precipitation-hardening (17-4 PH)	High strength; used in demanding corrosion-resistant and high-strength applications
Alloy steel (4140, 4340)	High strength; heat-treatable for wear-resistant parts
Heat-resistant (WC6, WC9, C12A)	Elevated-temperature and creep-resistant applications

10.2 Design Principles

- Choose the least demanding alloy that meets the mechanical, corrosion, and thermal requirements. Over-specifying alloy adds cost without benefit.
- Match minimum wall thickness recommendations to the alloy — duplex and precipitation-hardening grades may need marginally thicker walls than carbon steel.
- For a full grade list with chemical composition, mechanical properties, and typical applications, see Precimetal's Material Grade Specification Sheet.

11 COST & COMPLEXITY DRIVERS

A well-designed casting balances functional requirements against manufacturing cost. The following factors most consistently drive cost up or down. Consider each early in the design phase, when changes are still cheap to make.

11.1 Cost Drivers to Watch

- Tolerance callouts tighter than IS 11166 Class 2 / VDG P690 D2 — push machining into the process and add cost.
- Surface finish requirements tighter than 3.2 Ra as-cast — add machining or specialised finishing steps.
- Multi-piece tooling for undercuts or complex partings — raises tooling cost, though often justified vs. machining.
- Very thin walls (below 1.5 mm) — require process qualification and may increase scrap rate.
- Very thick sections (above 25 mm) — risk shrinkage porosity and may need chills or hollowing.
- Complex cored geometries — well-supported at Precimetal but still add core-manufacturing cost.

11.2 Cost-Reducing Design Choices

- Uniform wall thickness — reduces internal stress and simplifies process control.
- Generous fillets everywhere — improves both cast quality and pattern life.
- Cast holes at generous D/L ratios rather than deep tight-bore holes.
- Choose the least demanding alloy that meets requirements.
- Consolidate multiple machined parts into a single casting where geometry allows — often the biggest single cost saving.
- Consult early. A 30-minute conversation before tooling is committed regularly saves multiples of that time in downstream rework.

12 FILE FORMATS & ENGINEERING HANDOFF

12.1 Accepted File Formats

FILE TYPE	ACCEPTED FORMATS
3D CAD	STEP (.step, .stp), IGES (.igs, .iges), SolidWorks native
2D drawings	PDF, DWG, DXF
Additional formats	Contact us; most common formats can be accommodated

12.2 What to Include in Your RFQ

- 3D model in a preferred format above.
- 2D drawing showing critical dimensions, tolerances, and surface finish callouts.
- Material specification — either a specific alloy grade or a functional requirement (e.g. "corrosion-resistant, 500 MPa UTS minimum").
- Estimated annual volume and delivery expectations.
- Any regulatory, certification, or traceability requirements (IATF, PED, aerospace, etc.).
- Post-casting operations required (machining, heat treatment, surface finishing, sub-assembly).

12.3 What We Return

- Detailed quotation with tooling cost, per-part cost by volume band, and lead time.
- Design-for-manufacturing feedback — specific suggestions where design changes could reduce cost or improve reliability.
- For complex parts, a simulation-informed process recommendation (MAGMASOFT or ANSYS).

Engage Our Engineering Team

This guide is a starting point. The most consistent way to get a design manufactured reliably and cost-effectively is to bring us in early — before tooling is committed, ideally at the design-review stage.

Send your part model and requirement, and we'll return a detailed quotation with DFM feedback within 24 hours.

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