

Additively Manufactured Investment-Casting Patterns: Burnout, Shell Compatibility and Accepted-Casting Qualification

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Statement of Significance

A printable pattern is not yet a qualified investment-casting pattern. Release requires the complete pattern–shell–burnout–casting system to produce an accepted casting without leakage, shell damage, unacceptable residue, inclusions or dimensional failure.

Keywords: investment casting; vat photopolymerisation; pattern; burnout; ceramic shell; residual ash; accepted casting.

Abstract

Three verified topical sources address large-scale VPP master patterns, investment-casting shell/process development and techno-economic comparison of VPP routes. The evidence supports a workflow-level qualification boundary rather than a universal castability claim. Shell composition, thickness and permeability are mapped to the investment-casting review, not to a generic photopolymer source. Thermal analysis is tied to ISO 11358-1:2022 principles and to complete method conditions. The document does not treat an unspecified marketing ash value or a successful print as evidence of casting performance. RP-02 defines the shared qualification method.

1. Evidence boundary

Sameni et al. report a defined large-scale VPP route for investment-casting master patterns [1]. Pattnaik et al. review shell systems, permeability and process development [2]. Sartini et al. evaluate VPP routes at techno-economic workflow level [3]. These sources do not establish that every photopolymer, shell recipe, furnace schedule or casting alloy is interchangeable.

2. Topic-specific findings

- Pattern performance depends on print route, geometry, drainage, conditioning and dimensional state before shell building [1].
- Shell composition, thickness, permeability and preparation determine tolerance to pattern expansion, decomposition products and burnout history [2].
- Burnout must be evaluated as a coupled pattern–shell–furnace process rather than inferred from resin identity or an isolated ash claim [1,2].
- Economic comparison depends on the complete workflow and accepted-casting yield, not only print time or pattern cost [3].

3. Minimum reporting set

Measurand/control	Minimum method record	Required report
Pattern state	Dimensions, mass, wall thickness, drainage, supports and conditioning before shell building	Print route, post-processing, delay, geometry and uncertainty
Thermal behaviour	TGA/DSC/TMA on the actual pattern; use ISO 11358-1:2022 principles for TG	Heating rate, atmosphere/flow, sample mass, final temperature, dwell and residue basis
Burnout	Representative pattern–shell assembly with calibrated furnace/load record	Ramps, dwells, atmosphere, load arrangement, residue, gas path and failure timing
Shell	Production shell composition, layer count/thickness, permeability context and crack/leak inspection	Shell recipe/revision, drying history, permeability method and defect map
Casting	Alloy/process record plus surface, inclusions, dimensions and yield	Accepted casting is the endpoint; retain rejected castings and failure category

4. Failure interpretation

- A low residue measured under one TGA method is not a universal burnout or shell-compatibility result.
- Shell cracking can arise from pattern expansion, decomposition-gas pressure, shell state, furnace field or their interaction.
- A visually clean cavity does not exclude inclusions, surface defects or dimensional error in the casting.
- Pattern print success and dimensional accuracy do not substitute for accepted-casting yield.

5. 3Dresyns implementation examples

3Dresyns castable pattern-material routes are manufacturer-controlled implementation candidates, not independent evidence. No specific Perfect Cast grade is named in this Engineering Qualification Note because a controlled grade-specific TDS was not included in the reviewed evidence record.

Any future product example must identify the exact grade, TDS revision and accessed public link, and state that selection remains shell-, geometry-, furnace- and alloy-specific. This review makes no claim about the casting performance of an unspecified grade.

6. Limitations and priorities

The source set is small and process-specific. Numerical ash, expansion, permeability, cost or yield values cannot be pooled across dissimilar methods. Priorities are full-scale instrumented burnout, pattern–shell pressure/strain measurements, method-defined residue reporting and failure-cost models based on accepted castings rather than printed patterns.

7. Conclusions

- Investment-casting qualification belongs to the complete pattern–shell–burnout–casting workflow.
- Shell composition, thickness and permeability are supported by the casting-process source [2].
- Residual ash is method-dependent; avoid inferring performance from marketing ash values quoted without conditions.
- No 3Dresyns grade should be named publicly until its controlled TDS reference and revision are verified.

Declarations

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References

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