

Evidence-to-Decision Qualification Framework for Vat Photopolymerisation

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Statement of Significance

Published resin labels and isolated coupon results do not define a transferable process window. This framework separates evidence, measurement and qualification decisions so that topic-specific publications can remain concise, non-duplicative and traceable to the conditions that generated each result.

Keywords: vat photopolymerisation; qualification; evidence boundary; process window; uncertainty; decision criteria.

Abstract

This methodology paper defines the common qualification architecture used by the 3Dresyns Engineering Publication series. It distinguishes formulation evidence, process evidence, coupon evidence and representative-article evidence; requires unsuccessful and censored outcomes to remain visible; and links every qualified claim to a defined material, machine, exposure, geometry, post-processing, conditioning and measurement state. The document is a qualification framework rather than a quantitative literature review. Topic-specific evidence and standards belong in the corresponding technical note and are not reproduced here.

1. Scope and status

The framework applies to engineering qualification of vat-photopolymerised materials and workflows. It is not a consensus standard, product catalogue, regulatory pathway or substitute for an application-specific validation plan. It does not treat SLA, DLP, LCD/MSLA, continuous or volumetric exposure as interchangeable without evidence.

General background on photopolymerisation chemistry and on the additive-manufacturing process families referred to throughout this framework is available in [1] and [2]; neither is used here as evidence for any topic-specific proposition.

The experimental unit is the defined formulation processed on a defined machine using documented spectral conditions, irradiance or dose, layer or exposure strategy, geometry, washing, drying, post-cure, conditioning and test procedures. A change to any controlled element can require partial or complete requalification.

2. Evidence hierarchy

- A compositional feature supports a screening hypothesis, not a finished-part claim.
- A controlled coupon supports a method- and state-specific material statement.
- A representative article supports only the bounded application and workflow that were tested.
- Manufacturer-controlled product documentation establishes identity and intended processing context; it is not independent scientific evidence.
- Regulatory approval, biological suitability and safety require their own evidence and cannot be inherited from a resin name or ingredient.

3. Minimum qualification architecture

Control block	Minimum record	Decision consequence
Material state	Product/version, batch, age, storage, conditioning and preparation	Prevents transfer between nominally similar but uncontrolled states
Machine and exposure	Architecture, wavelength, measured irradiance/dose, optics and exposure strategy	Defines the optical process boundary
Geometry and location	CAD, orientation, supports, build position and relevant feature dimensions	Makes scale and position effects visible

Post-processing	Wash medium/time, drying, post-cure spectrum/dose and delay	Links final state to the complete workflow
Measurement	Method, instrument, calibration, specimen, conditioning, uncertainty and censoring rules	Makes results auditable and comparable
Acceptance	Use case, failure consequence, numerical or categorical criterion and exclusions	Restricts the qualified claim to the tested boundary

4. Evidence-to-decision workflow

1. Define the use case, failure consequence and acceptance criterion before selecting a material or test.
2. Freeze a traceable material–machine–geometry–post-processing baseline.
3. Measure the mechanism-relevant variable and the finished-article response using independent replicates.
4. Challenge the window with credible changes in lot, position, time, temperature, conditioning and operator where relevant.
5. Qualify only the narrow claim supported by the tested boundary; document exclusions and retest triggers.

5. Failure records and uncertainty

Failed, censored and inconclusive specimens must remain in the evidence record. Removing them before analysis biases the process window. Replicates should represent independent builds and, where relevant, material lots rather than repeated readings of one specimen. Measurement uncertainty, registration choices and detection limits must accompany any transferable value.

6. Relationship to topic-specific publications

Each topic-specific Engineering Qualification Note must contain only its subject-specific mechanisms, evidence, standards, measurement controls, limitations and implementation examples. It should cite this framework once instead of reproducing the common sections. A note that cannot support its title with topical evidence must be narrowed, merged or held.

7. Limitations

This document provides no universal acceptance thresholds and reproduces no quantitative literature results. Those values are meaningful only with the conditions reported by their source and therefore belong in topic-specific evidence notes. Standards and controlled documents must be checked for current edition and applicability immediately before qualification.

8. Declarations

Funding: no external funding declared. Competing interest: the author is associated with 3Dresyns by Resyner Technologies S.L. Data availability: no new experimental dataset was generated.

References

- [1] Ali Bagheri, Jianyong Jin. Photopolymerization in 3D Printing. ACS Applied Polymer Materials. 2019;1(4):593–611. <https://doi.org/10.1021/acsapm.8b00165>
- [2] Jeffrey W. Stansbury, Mike J. Idacavage. 3D printing with polymers: Challenges among expanding options and opportunities. Dental Materials. 2016;32(1):54–64. <https://doi.org/10.1016/j.dental.2015.09.018>