

Standards-Landscape and Gap Analysis for Photopolymer Additive Manufacturing: Coverage, Conflicts and Priorities

A bounded standards-landscape review separating public standard roles from photopolymer-specific corpus evidence

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Abstract

Photopolymer additive manufacturing sits inside a broader additive-manufacturing standards landscape, but the evidence used to map that landscape must be distinguished from the evidence needed to infer detailed normative requirements. This Engineering Review uses six external ISO/ASTM public records to identify visible standards roles in vocabulary, process and production-site qualification, polymer-part property classification, characteristics and test methods, geometric capability assessment, and an under-development cross-AM failure-mode/risk-mapping work item [1-6]. None of those six external anchors is photopolymer- or vat-photopolymerisation-specific. The photopolymer-specific side of the analysis rests entirely on ER-100, an internal corpus review that documents the need to preserve material, process, cure, orientation, washing, post-cure, ageing, surface and interface state when evidence is transferred across the photopolymer corpus [7]. Accordingly, this article maps interfaces rather than claiming hidden omissions inside standards. It does not reconstruct paid normative clauses, infer legal conflicts, or assert that a standard fails to require a photopolymer control. ISO/ASTM DIS 52954-1 is treated at every mention as a Draft International Standard under development, cross-AM and not VPP-specific. The resulting gap analysis identifies where visible standards roles and state-resolved photopolymer evidence must be connected explicitly. Priority ordering is presented only as an authorial engineering synthesis, not as an externally established ranking. A worked standards-to-evidence mapping exercise distinguishes a local evidence interface from an unverified claim about missing normative requirements.

Keywords: standards landscape; photopolymer additive manufacturing; vat photopolymerisation; qualification; evidence transfer; state variables; gap analysis; ISO/ASTM

1. Scope and ownership

ER-491 examines the standards landscape surrounding photopolymer additive manufacturing at the level supported by the active evidence base. Its subject is the interface between publicly visible standards roles and the state-resolved evidence architecture required to interpret photopolymer manufacturing results. It is not a substitute for the normative text of any standard and does not create a new standard.

ER-392 retains ownership of the minimum-information and reporting schema for photopolymer additive-manufacturing studies. ER-484 retains ownership of the standardised failure taxonomy and minimum failure record. ER-491 may identify those controlled corpus objects as adjacent interfaces, but it does not reproduce them or infer that an external standard omits their fields.

2. Evidence basis and defining public limitation

The external standards base comprises six ISO/ASTM public records [1-6]. Those records support identity, public status and the bounded role visible in the official public record. Their paid normative clauses, annexes and tables were not read for this review. No absence inside a standard is therefore inferred from this base.

Critically, zero of the six external anchors [1-6] is photopolymer- or VPP-specific. The photopolymer-specific side of ER-491 comes only from ER-100 [7], which is internal corpus evidence rather than external standards evidence. ER-100 can support the corpus-level observation that standards roles must be connected explicitly to photopolymer state variables; it cannot establish an external normative requirement, omission, legal conflict or current standards status.

This separation controls the whole article. The term photopolymer additive manufacturing in the title identifies the application domain in which standards are being interpreted; it does not mean that the external standards base contains a photopolymer-specific standard.

3. Publicly visible standards roles

ISO/ASTM 52900:2021 provides the public vocabulary and fundamentals frame for additive manufacturing [1]. ISO/ASTM 52920:2023 provides a public process- and production-site-qualification frame [2]. ISO/ASTM 52924:2023 addresses classification of polymer AM part properties [3]. ISO/ASTM 52927:2024 addresses main characteristics and corresponding test methods [4]. ISO/ASTM 52902:2023 addresses geometric capability assessment of additive-manufacturing systems using test artefacts [5].

ISO/ASTM DIS 52954-1, a Draft International Standard under development, is a cross-AM work item on common failure modes used for process risk mapping [6]. It is not VPP-specific and is not a published International Standard. ER-491 uses it only as evidence that the public standards landscape includes an under-development cross-AM failure-mode/risk-mapping work item; no draft requirement is reconstructed.

4. Coverage as an interface map

In this review, coverage means the relationship between a publicly visible standards role and a photopolymer state variable or evidence-transfer problem documented in the controlled corpus. It does not mean clause-by-clause completeness. A defensible statement therefore has the form: a public standards role addresses one domain, while the photopolymer corpus identifies an additional state that must remain visible when evidence is transferred. The interface requires explicit qualification. It does not justify the statement that the standard fails to require that state.

ER-100 documents a recurring transfer boundary: a test method or general qualification frame can coexist with unresolved photopolymer-specific state variables such as cure state, orientation, support strategy, washing, post-cure, ageing, surface condition or interface condition [7]. These variables can change the meaning or transferability of a result without implying that any named external standard is deficient.

5. Six interface classes

The active evidence supports six bounded classes of standards-to-corpus interface. They are analytical classes for ER-491, not conclusions about missing normative clauses.

Interface class	Public role	ER-491 boundary
Vocabulary / state	A1: common AM vocabulary and fundamentals	Preserve photopolymer state variables when terminology is transferred; no omission claim.
Process/site / state	A2: process and production-site qualification	Connect general qualification framing to material-process-workflow state; no missing-clause claim.
Polymer properties / history	A3: classification of polymer part properties	Keep property classification distinct from cure and process history; no reporting-field absence claim.
Characteristics / transfer	A4: characteristics and corresponding test methods	Evaluate transferability across material, machine and post-process states; no hidden requirement inferred.
Geometry / material state	A5: geometric capability assessment	Keep geometric capability separate from material/process qualification.
Published / developing	A6: cross-AM Draft International Standard under development on failure modes/risk mapping	Track draft status without treating it as published, VPP-specific or as ER-484 taxonomy content.

6. Conflict: what can and cannot be claimed

The word conflict in ER-491 is limited to demonstrable scope, terminology or coverage tension between controlled records. On the present source base, the article cannot establish a legal conflict, a compliance defect, a committee error or a contradiction hidden inside paid normative text.

A practical tension can still exist when two evidence objects answer different questions. For example, a geometric capability assessment and a material/process qualification are distinct evidence objects [5,7]. Treating one as a substitute for the other would be an evidence-transfer error even if neither standard nor corpus object is defective. ER-491 uses conflict in this restrained, interface-level sense.

7. Photopolymer state variables as the transfer boundary

ER-100 identifies material and workflow state as central to qualification across the photopolymer corpus [7]. In that corpus, a result can depend on formulation identity, exposure, orientation, support strategy, washing, post-cure, ageing, surface condition and interfaces. These states are not introduced here as universal normative fields; they are internal corpus variables that must be visible when evidence is interpreted or transferred.

The engineering consequence is a two-layer reading. The external record establishes what a standards object publicly addresses. The internal photopolymer corpus establishes which state variables may control transferability inside this catalogue. ER-491's task is to connect those layers without pretending that the second layer is already encoded in the first.

8. Boundary with ER-392 and ER-484

ER-392 owns the minimum-information standard proposed within this Engineering Review corpus. ER-491 can point to reporting as an interface problem, but it does not restate ER-392's field set and does not claim that any external standard lacks those fields.

ER-484 owns the standardised failure taxonomy and minimum failure record. ISO/ASTM DIS 52954-1, a Draft International Standard under development, remains a cross-AM failure-mode/risk-mapping work item [6]. It cannot be used here to define, reproduce or compete with ER-484's taxonomy or record architecture.

9. Priorities as authorial engineering synthesis

No external source in the active base establishes a universal ranking of priorities. The ordering below is therefore an authorial engineering synthesis for this corpus, not a standards mandate.

First, preserve the distinction between public standards roles and photopolymer-specific corpus evidence. Second, make evidence-transfer interfaces explicit whenever a result crosses material, machine, cure, post-process or ageing states. Third, keep draft work items visibly separate from published standards. Fourth, preserve ownership boundaries so that ER-392 defines reporting architecture and ER-484 defines failure-record architecture rather than allowing ER-491 to become a competing schema. Fifth, update the landscape when authoritative public records change, because the status of standards and work items is time-dependent.

These priorities are chosen for decision value within the Engineering Review corpus: they reduce the risk of overclaiming, false transfer and accidental duplication. They are not claimed to be the priorities of ISO, ASTM, regulators, industry or any jurisdiction.

10. A bounded standards-to-evidence decision architecture

A standards-landscape decision can be kept auditable by recording four elements for each question: the external standards object and its public role; the photopolymer state variable or transfer problem documented internally; the exact interface being evaluated; and the claim boundary that prevents an absence or requirement from being inferred without normative text.

This architecture does not decide compliance. It indicates when the available public record is sufficient for landscape mapping and when controlled normative text, application-specific standards, regulatory analysis or additional evidence would be required before a stronger conclusion could be made.

11. A standards-to-evidence mapping exercise

The proposed mapping exercise begins with a specific engineering question rather than a list of standard numbers. Suppose an organisation needs to establish the geometric capability of a declared manufacturing configuration and the stability of a material property after post-processing. These are two questions. The public role of a geometric-capability standard can identify a relevant standards object, while the material-property question requires its own applicable method and state definition. One answer should not be used to close the other.

For each question, the map would record the official standards identity and public scope, whether the controlled normative text was consulted, the experimental object being assessed and the claim supported by the resulting evidence. If only a public record was available, the map would stop at the role visible there. It would not fill an unread clause with assumptions about what the standard must require.

This exercise can reveal an interface requiring work without identifying a defect in the standard. For example, the local manufacturing record may fail to preserve post-cure state even when the test result is traceable to a recognised method. The demonstrable gap is then in the connection between local state and evidence, unless inspection of the normative text supports a stronger conclusion.

12. Maintain identity and status without reconstructing requirements

A proposed maintenance record would preserve edition, publication or development status, authoritative locator and the date on which status was checked. A draft and a published edition should remain distinguishable, as should a document that has been replaced and the replacement itself. The local evidence may have been generated under an earlier edition; its continuing relevance requires assessment rather than an automatic date substitution.

Where terminology changes, the record should state whether the underlying technical meaning changed or only its label. Where a requirement changes, that conclusion must come from the applicable text, not from the title or a news summary. The impact assessment would then identify which local tests, procedures or declarations may require review.

The result is an auditable landscape with explicit access depth and application boundaries. It supports planning for normative review and experimental work, but does not certify compliance. Its value can be evaluated by whether another analyst can reproduce the route from an engineering question to the appropriate controlled source and identify where additional access or evidence is still necessary.

Conflict resolution between standards and validation evidence

Two normative documents can address adjacent layers without defining interchangeable acceptance criteria. When their scopes overlap, the reviewer should record edition, applicability, normative versus informative status, controlled process stage and the responsible acceptance authority. Apparent inconsistency may result from applying a material test method to finished-device acceptance rather than from contradictory standards.

A standards gap is not demonstrated merely because a keyword is absent from a title. Establish the relevant requirement, the missing measured variable, and why existing methods cannot close the uncertainty for the specified resin and process state. Suggested tests must be flagged as authorial engineering synthesis rather than attributed to the standard.

Supplementary critical engineering analysis

Standards applicability matrix

A standards landscape is most useful when structured by regulated object, manufacturing technology, property being measured, specimen or component state and intended use. A general terminology standard, a machine-acceptance method and a device-specific requirement have different normative functions. Combining them into an undifferentiated compliance checklist risks implying coverage that is not present. An applicability matrix should cite edition, status, clause-level scope where accessible, and the reason a particular requirement is relevant.

Gap classification and evidence hierarchy

A genuine gap should be distinguished from an inaccessible full standard, an unpublished proposed method and an existing test method not yet validated for the intended photopolymer state. Priority should be assigned using consequence, frequency of use and the feasibility of reproducible interlaboratory evidence. Recommendations here are a standards-mapping synthesis, not an assertion that any body has approved a new normative requirement.

Critical synthesis: Testing the proposed standards gap rather than assuming it

A claimed standards gap must be framed as a falsifiable mismatch between the decision to be made and the measurement or requirement actually available. First establish the applicable normative edition and scope from the controlled text; then identify whether specimen conditioning, conversion history, formulation state, machine capability or finished-part duty lies outside that scope. Absence of the word photopolymer in an official summary does not demonstrate absence of coverage. Where the full normative text has not been inspected, the finding should remain an unresolved applicability question rather than a verified gap.

A proposed validation exercise would compare independent laboratories using common liquid-resin characterisation, post-cure records, test geometry and environmental conditioning, and would report both between-site dispersion and within-site repeatability. The output is not a universal process acceptance limit; it is evidence about whether the proposed reporting and test interface can support cross-site interpretation. Any suggested priority ranking should disclose the assumed application severity and cost of a wrong decision.

A testable hierarchy for identifying standards gaps

A gap analysis must begin with the controlled object and its state: liquid formulation, green article, post-cured coupon, finished device or manufacturing system. A standard specifying terminology or a generic test method cannot be used as evidence of application-specific conformity. For each alleged gap, identify the property whose uncertainty blocks a decision, the available method's actual scope and the consequence of using an unvalidated surrogate. A documented mismatch in scope is more informative than simply counting standards with photopolymer keywords in their titles.

An interlaboratory study of a proposed method should control specimen geometry, orientation, thickness, resin lot, conversion history, conditioning and instrument calibration. Repeatability and reproducibility are separate properties, as are measured-property uncertainty and acceptance limits chosen by an application authority. Where test outcomes are sensitive to post-processing, the validated method must describe that state explicitly rather than assuming nominal exposure settings yield equivalent specimens.

The resulting roadmap should label each item as an established normative requirement, an informative industry practice, a proposed research method or an unmet evidence need. Changing an edition may affect terminology or requirements without changing the underlying physical uncertainty. The review therefore recommends an evidence-to-decision matrix, not a new universal certification scheme for photopolymer articles.

13. Limitations

The external evidence is intentionally shallow: [1-6] are used from public official records rather than controlled normative full text. Therefore no clause, mandatory requirement, annex content, hidden field, mandatory test frequency, acceptance threshold or application-specific requirement is quoted, paraphrased or reconstructed from them.

Zero of the six external anchors is photopolymer- or VPP-specific. The photopolymer-specific interpretation rests on internal corpus evidence [7]. ISO/ASTM DIS 52954-1, a Draft International Standard under development, is cross-AM and not VPP-specific [6]. Priority ordering is authorial synthesis. The review does not establish legal conflicts, compliance defects or universal standards gaps.

14. Conclusions

The standards landscape relevant to photopolymer additive manufacturing is best interpreted as a set of public roles that must be connected carefully to state-resolved evidence. The active external base supports vocabulary, qualification, property-classification, test-method, geometric-capability and under-development cross-AM risk-mapping roles [1-6]. It does not support a claim that any named standard omits a photopolymer requirement.

Within that boundary, ER-491 identifies the engineering problem that matters: evidence can become misleading when a general standards role is transferred into a photopolymer decision without preserving the material, process and specimen state documented in the corpus [7]. The resulting gaps are interface gaps, not allegations of normative absence. A useful standards strategy is therefore one that preserves scope, state, status and ownership at every transfer.

References

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Competing interests

The author is Founder, CEO and CTO of 3Dresyns by Resyner Technologies S.L. The company develops and supplies photoresins and related process materials. No proprietary formulation, manufacturing sequence, process window or comparative product recommendation is disclosed.

Data availability

No new experimental dataset was generated for this review. The photopolymer-specific interpretation draws on the internal corpus review ER-100 [7].

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