

Engineering VPP Photopolymers Across Thermal, Mechanical and Functional Envelopes

Portfolio screening and application-specific verification without universal cure or medical-routing rules

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Highlights

- Engineering VPP selection requires thermal, mechanical, chemical, dimensional and functional requirements to be considered together.
- Portfolio maps and family names generate candidates; current product-specific TDS and controlled reports define retained claims.
- Shore hardness, modulus, HDT or a commercial analogue label cannot establish the complete service envelope alone.
- Validation methods and acceptance criteria are selected from intended service conditions and failure modes; no universal engineering ISO battery applies.
- Degree of conversion can be a validated formulation-specific process indicator but is not a universal release threshold.
- For a finished medical device, requirements and evidence gaps are defined before material-family selection.

Abstract

Engineering VPP photopolymers span rigid, tough, high-temperature, chemically resistant and special-function candidate families. Selection is a multi-constraint problem: the named part geometry, loads, temperature, exposure media, lifetime, dimensional tolerance, manufacturing process and applicable product requirements determine the useful envelope.

This paper presents a portfolio-screening framework rather than fixed grade rankings or universal property ranges. Numerical data and product compatibility must be tied to the exact current TDS, specimen preparation, method, conditioning and processing route. Analogue labels and family-level claims do not establish equivalence to conventional thermoplastics or transfer automatically between variants.

Engineering validation is application-specific. For medical-device uses, finished-device intended purpose, contact, duration, classification, biological evaluation and manufacturing validation are defined before candidates are selected. A commercial family is not a regulatory route.

Keywords VPP · engineering photopolymers · thermal envelope · mechanical screening · chemical resistance · flammability · ESD · validation plan

Source use. Controlled portfolio and application documentation is mapped in [1–4]; mechanical, thermal, chemical and AM method evidence in [5–10]; ESD and risk-management boundaries in [11–12].

1. Scope and platform boundary

WP-07 covers engineering photopolymer candidates processed by conventional SLA, DLP and LCD VPP. Two-photon polymerisation and powder-bed fusion use different material and process mechanisms and require separate evidence. Even within SLA, DLP and LCD, wavelength, irradiance, optics, layer formation, temperature and post-processing can change cure and final properties [1–4].

The screening framework applies to structural, thermal, chemical, impact, flammability, electrostatic and other functional needs. It does not assert that one portfolio map or grade is suitable for every machine or service condition.

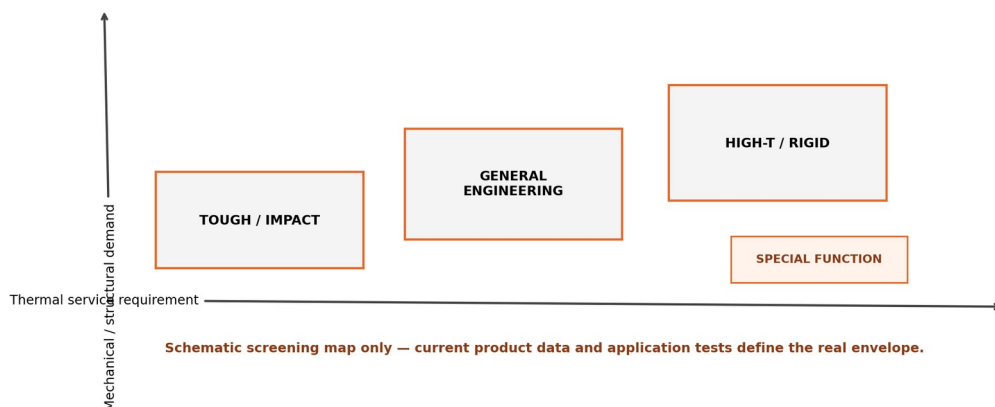


Figure 1. Schematic engineering screening map. It intentionally contains no product-specific numerical property claims.

2. Candidate generation across coupled envelopes

Begin with the intended article and foreseeable failure modes. A rigid housing, compliant bracket, high-temperature fixture, solvent-exposed component and ESD-controlled assembly ask different questions even when their Shore hardness is similar. Feature thickness, orientation, stress concentration, ageing and manufacturing variability also affect structural response.

Commercial families such as general engineering, tough, high-temperature, chemical-resistant, flame-resistant or ESD can organize the search. The retained candidate must then be linked to the current product-specific TDS and, for quantitative or functional claims, the exact controlled test report. Product names and availability can change, so this paper does not freeze a 2026 catalogue as a permanent specification.

KEY INSIGHT

A property-map position is a screening input. The decision requires a named candidate, controlled data and tests linked to the intended service and failure modes.

3. Requirement and evidence matrix

Requirement family	Screening input	Possible evidence	Boundary
Structural	Loads, stiffness, failure mode, geometry	Tensile, flexural, impact, fatigue or part test	Shore alone is insufficient
Thermal	Temperature, time, load and cycling	HDT plus service simulation	HDT is not a universal service temperature
Chemical	Fluid, concentration, time, temperature and stress	Immersion and retained-property testing	Short-term screening is not lifetime proof
Flammability	Applicable product requirement, specimen and thickness	UL 94 or other applicable route	Classification is specimen/material/thickness-specific
ESD/electrical	Target range, humidity and geometry	Surface/volume resistance on controlled specimens	Verify the production part where required
Dimensional	Tolerance, orientation, ageing and environment	Metrology and stability plan	Process- and geometry-specific

HDT, Shore hardness and single-point strength values are useful descriptors but do not define fatigue, creep, thermal cycling, chemical ageing or the performance of thin walls and lattices. Similarly, PEEK-like or another analogue label is a commercial comparison and does not make a cured photopolymer chemically or thermally equivalent to the named thermoplastic.

4. Application-specific mechanical and physical test plan

Engineering validation must be defined from the intended service conditions and failure modes. Relevant methods can include tensile, flexural, impact, heat-deflection, chemical-resistance, flammability, electrical or dimensional tests, but the selected methods and acceptance criteria vary by application. Degree of conversion may be monitored when its method and relationship to final performance have been validated for the named formulation and process. It is not a universal release threshold.

FAILURE MODE	POSSIBLE METHOD	ACCEPTANCE BASIS
• Yield / fracture • Deflection • Heat distortion • Chemical change • Ignition / flame • Electrical drift	• Tensile / flexural / impact • Stiffness + geometry test • HDT or service simulation • Immersion + property retention • Applicable flammability route • Surface/volume resistance	• Design load and margin • Dimensional function • Named temperature/time • Named fluid/time/temperature • Certified scope + product use • Application ESD requirement

Figure 2. Selectable test-plan matrix. Methods and acceptance criteria are linked to failure modes rather than applied as a fixed battery.

5. Functional-claim boundaries

5.1 Thermal and chemical service

A heat-deflection result is method-, load- and specimen-specific. Continuous or cyclic service temperature requires application evidence. Chemical resistance must identify medium, concentration, temperature, duration, stress state, measured change and acceptance criteria. Short-term immersion screening cannot be converted into a universal lifetime claim.

5.2 Flammability

UL 94 classifications are tied to the evaluated material, specimen preparation and thickness. A different thickness or production configuration must be assessed against the applicable certification and end-product use requirements. It is inaccurate to describe every subsequent verification automatically as re-certification.

5.3 ESD and other electrical functions

Electrical resistance can depend on formulation, conditioning, humidity, geometry, surface preparation and measurement method. A TDS value supports screening; production-part verification and the relevant ESD control plan determine application suitability.

6. Finished-device and biological-evaluation boundary

For a finished medical device, define the intended purpose, contact, duration, classification and biological-evaluation requirements before material selection. Product families with relevant controlled documentation may be considered as candidates, but the final device manufacturer remains responsible for manufacturing validation, biological evaluation and regulatory conformity.

Biological evaluation may be irrelevant for many non-body-contact engineering applications, but chemical restrictions, worker protection, consumer-product obligations, environmental requirements or other market rules can still apply. The selection record should identify all applicable constraints rather than marking safety or compliance as skipped.

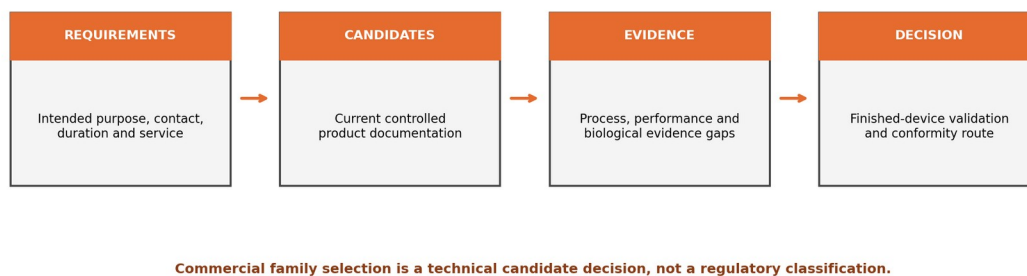


Figure 3. Finished-device requirements and evidence gate. Candidate-family selection does not determine device classification or conformity.

7. Minimum selection and validation record

- Intended article, service environment, design life, quantitative requirements and foreseeable failure modes.
- Exact product, variant, batch where relevant, TDS revision and controlled report references.
- Printer, wavelength/spectrum, irradiance, exposure, orientation, post-processing and conditioning.
- Selected test methods, specimen/part geometry, sampling, acceptance criteria and decision owner.
- Chemical media, concentration, temperature, duration and property-retention criteria where applicable.
- Change-control triggers for formulation, additive, process, equipment, geometry, supplier or intended use.

8. Limitations

- This paper does not freeze the current catalogue or verify unreferenced numerical product claims.
- Schematic family maps do not establish material equivalence, application lifetime or regulatory suitability.
- HDT, Shore hardness, degree of conversion and analogue labels are insufficient as stand-alone release criteria.
- Long-term ageing, fatigue, creep, thermal cycling and stressed chemical exposure require dedicated plans.
- Composite, filled, pigmented and additive-modified formulations require variant-specific evidence.
- Medical-device conclusions remain at finished-device level and with the legal manufacturer.

9. Conclusions

- Engineering VPP selection is a coupled thermal, mechanical, chemical, dimensional and functional problem.
- Portfolio families and maps generate candidates; current controlled data and application tests decide suitability.
- Validation is built from service conditions and failure modes, not a universal ISO battery or conversion threshold.
- Flammability, ESD and chemical-resistance claims retain specimen, method and application boundaries.
- For medical-device uses, finished-device requirements and evidence gaps precede commercial-family selection.

Revision note

Version 5.3 removes the universal DC release threshold and engineering ISO battery; replaces automatic commercial-family medical routing with a finished-device requirements gate; qualifies UL 94, chemical, thermal, ESD and analogue claims; and makes current product-specific controlled documentation the evidence source for retained numerical claims.

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Disclosure. Dr. Juan Segurola is founder and Scientific Director of 3Dresyns by Resyner Technologies S.L. Product suitability depends on the complete material–process–printer–application system.

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