

Fatigue and Time-Dependent Deformation in Vat-Printed Thermosets: A Qualification and Evidence-Gap Note

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3Dresyns by Resyner Technologies S.L.

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Statement of Significance

Static strength or hardness does not establish cyclic life, creep resistance or retained clamping force. The current topical source set supports a bounded fatigue and material-state discussion, but it does not contain primary service-condition creep-compliance or stress-relaxation-modulus data for vat-printed thermosets.

Keywords: fatigue; time-dependent deformation; creep; stress relaxation; vat photopolymerisation; qualification; evidence gap.

Abstract

This note separates evidence that is present from measurements still required for application release. The cited studies address curing-dependent thermo-viscoelasticity, heat-assisted VPP processing, network development during photopolymerisation and a defined dental fatigue comparison. They do not provide a service-life creep or stress-relaxation dataset for a vat-printed thermoset. Creep and relaxation are therefore treated as qualification requirements and explicit evidence gaps. ISO 899-1:2017, ASTM D2990-17(2025) and, where fibre reinforcement makes it applicable, ISO 13003:2003 provide method anchors. RP-02 defines the shared qualification logic.

1. Evidence boundary

This review found no primary study in its cited set reporting creep compliance or stress-relaxation modulus for a vat-printed thermoset under service conditions. Creep and relaxation are therefore treated here as qualification requirements with an identified evidence gap, not as reviewed performance findings.

Sekmen et al. quantify curing-dependent thermo-viscoelastic and shrinkage behaviour [1]; this is relevant to network evolution but is not a service-creep dataset. Lim et al. evaluate heat-assisted VPP and resulting physical and mechanical characteristics [2]. Sarkar et al. measure network development during photopolymerisation [3]. Bora et al. provide a bounded dental fatigue comparison [4]. None establishes a universal durability ranking among commercial VPP resins.

2. Topic-specific findings

- Curing history changes the thermo-viscoelastic state and shrinkage response of a photopolymer network [1].
- Processing temperature can change conversion-related and mechanical outcomes; the resulting state must be documented rather than inferred from the resin name [2].
- Network structure and properties evolve together during photopolymerisation, so conversion history belongs in the qualification record [3].
- A fatigue result is transferable only within its specimen, environment, loading mode, frequency and failure definition; the dental comparison in [4] is application-specific.
- Service creep and stress relaxation remain unfilled evidence requirements in this source set and must be measured for load-bearing or force-retaining uses.

3. Minimum measurement and qualification set

Measurement/condition	Method anchor	Minimum report
Fatigue	Stress- or strain-controlled method matched to the part; ISO 13003:2003 only for fibre-reinforced plastics where its scope applies	Waveform, ratio, frequency, environment, specimen/orientation, failure criterion and predeclared runout cycle count
Tensile creep	ISO 899-1:2017; ASTM D2990-17(2025) where its tensile, compressive, flexural creep or creep-rupture scope is selected	Stress, temperature, humidity/medium, conditioning, strain-time curve, compliance calculation and test duration
Stress relaxation	Validated fixed-strain method selected for the geometry and use case; no universal VPP method is asserted here	Applied strain, strain-control verification, gripping, temperature, medium, stress-time curve and retained-force criterion
Material state	Production-equivalent print, wash, dry, post-cure and conditioning record	Grade/lot, printer, spectral dose, orientation, geometry, timing, conversion proxy and glass-transition method
Damage and censoring	Stiffness tracking, fractography and defined stop/runout rules	Failure location, invalid tests, censored specimens and build/lot-level replication

4. Method and interpretation limits

- ISO 899-1:2017 specifies tensile creep for plastics; its result is not interchangeable with a different loading mode or specimen state.
- ASTM D2990-17(2025) covers several creep and creep-rupture modes. Report the selected procedure; do not pool unlike modes or methods.
- ISO 13003:2003 addresses fatigue of fibre-reinforced plastics. It is not presented as a universal standard for unfilled VPP thermosets.
- A runout is a censored result, not proof of infinite life. State the predeclared cycle limit and include runouts in the analysis.
- Accelerated temperature or frequency is useful only when the shift model and failure mechanism remain valid for the intended service condition.

5. 3Dresyns implementation examples

Rigid, tough, flexible and elastic 3Dresyns families are manufacturer-controlled implementation candidates, not independent fatigue, creep or relaxation evidence. No family-level durability ranking is made in this Engineering Qualification Note. Any product-specific example must identify an exact grade and controlled TDS revision, then freeze the printer, exposure, wash, dry, post-cure, conditioning and test state.

WP-02 and WP-10 may support screening terminology after their corrected versions are approved, but they cannot replace long-duration or cyclic testing on production-equivalent articles. A product example must be removed if its controlled documentation or intended-use boundary cannot be verified.

6. Limitations and research priorities

The topical evidence set is small, formulation-specific and heterogeneous. It contains no primary service creep-compliance or stress-relaxation-modulus dataset for a vat-printed thermoset. Priorities are open fatigue datasets with runouts, long-duration creep and retained-force studies, environment and temperature matrices, and validation of acceleration models against unchanged failure mechanisms.

7. Conclusions

- Fatigue evidence must remain bounded to the tested material-process-specimen-environment state.
- Creep and stress relaxation are qualification requirements in this note, not literature-supported performance claims.
- Current method anchors are ISO 899-1:2017, ASTM D2990-17(2025) and, only within its fibre-reinforced-plastics scope, ISO 13003:2003.
- No 3Dresyns grade should receive a durability claim without application-specific cyclic and time-dependent testing.

Declarations

Funding: none. Competing interest: the author is Founder and Scientific Director of 3Dresyns by Resyner Technologies S.L. No new dataset was generated. Juan Seguroola verified the article and accepts responsibility.

References

- [1] Kubra Sekmen, Thomas Rehbein, Michael Johlitz, Alexander Lion, Andrei Constantinescu. Curing-dependent thermo-viscoelastic and shrinkage behaviour of photopolymers. *Mechanics of Materials*. 2023;179:104566. <https://doi.org/10.1016/j.mechmat.2023.104566>
- [2] Jung-Hwa Lim, Seung-Ho Shin, Young-Eun Jung, Hongseok An, Jong-Eun Kim. Influence of heat-assisted vat photopolymerization on the physical and mechanical characteristics of dental 3D printing resins. *Scientific Reports*. 2025;15:1710. <https://doi.org/10.1038/s41598-025-85529-7>
- [3] Swarnavo Sarkar, Paula J. Baker, Edwin P. Chan, Sheng Lin-Gibson, Martin Y. M. Chiang. Quantifying the sensitivity of the network structure and properties from simultaneous measurements during photopolymerization. *Soft Matter*. 2017;13(21):3975-3983. <https://doi.org/10.1039/C7SM00419B>
- [4] Pranit V. Bora, Nathaniel C. Lawson, Daniel A. Givan, Celin Arce, Howard Roberts. Enamel wear and fatigue resistance of 3D printed resin compared with lithium disilicate. *The Journal of Prosthetic Dentistry*. 2025;133(2):523.e1-523.e9. <https://doi.org/10.1016/j.prosdent.2024.10.024>

Standards

ISO 899-1:2017. Plastics - Determination of creep behaviour - Part 1: Tensile creep. <https://www.iso.org/standard/72819.html>

ASTM D2990-17(2025). Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics. <https://store.astm.org/d2990-17r25.html>

ISO 13003:2003. Fibre-reinforced plastics - Determination of fatigue properties under cyclic loading conditions. <https://www.iso.org/standard/32190.html>

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