

The 3Dresyns Wedge Method for Qualitative VPP Screening

A fixed-protocol comparative observation before instrumented mechanical characterization

Dr. Juan Seguroloa, founder and Scientific Director · 3Dresyns by Resyner Technologies S.L. · General Etxague 15B, 20003 Donostia / San Sebastián, Gipuzkoa, Spain · info@3dresyns.com · www.3Dresyns.com

Highlights

- The Wedge Method is a qualitative comparative observation performed after a defined print, cleaning, post-cure and conditioning workflow.
- Manual assessment can take less than five minutes after specimen preparation; total elapsed workflow time must be reported separately.
- Observed deformation or fracture location depends on coupled material, specimen, process, support, load and operator variables.
- The result must not be converted into modulus, toughness or strength without independent validation against instrumented measurements.
- The method can supplement process development but is not a validated minimum-post-cure test or a stand-alone batch-release test.

Abstract

The 3Dresyns Wedge Method uses a graduated-thickness VPP specimen to record deformation, fracture and recovery under a defined manual procedure. Its purpose is to compare candidate formulations or processing conditions rapidly after specimens have completed the required printing, cleaning, post-curing and conditioning steps.

The response is qualitative. Fracture or bend location cannot be interpreted as a direct measure of modulus, toughness or strength because applied force, support geometry, specimen dimensions, local defects, cure gradient, anisotropy, residual stress, strain rate and operator technique are coupled. Category assignment is provisional and requires instrumented confirmation when quantitative properties or design decisions are involved.

A Wedge specimen can support screening of Fine Tuner or other process changes, comparison of candidate post-cure conditions and supplementary process monitoring against a retained reference. It does not replace ISO 527 characterization, establish a validated minimum post-cure or release a resin batch by itself.

Keywords VPP · qualitative screening · Wedge Method · comparative observation · mechanical characterization · process control · ISO 527

Source use. The controlled Wedge/SMSP procedures and formulation documentation are identified in [1–3]; scientific and mechanical-screening context in [4–9,14]; applicable mechanical methods in [10–13].

1. Intended use

VPP development often requires comparison of several formulation, exposure or post-processing conditions before full mechanical characterization. The Wedge Method provides a structured visual observation for this early screening stage. It is most useful when the material, printer, geometry, orientation, cleaning, post-cure, conditioning and operator sequence are held constant.

Manual Wedge assessment takes less than five minutes after the specimen has completed the defined printing, cleaning, post-curing and conditioning workflow. Instrumented tensile characterisation requires additional specimen preparation, conditioning and test time defined by the applicable laboratory protocol. The Wedge assessment does not replace that characterisation.

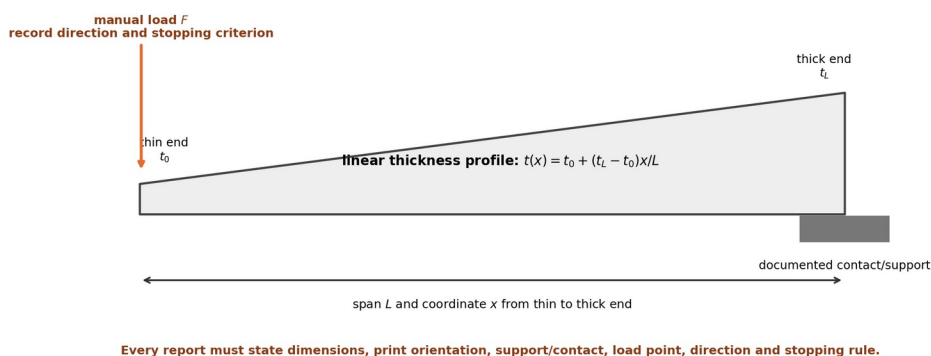


Figure 1. Required geometry and loading definition for a Wedge report. Dimensions shown symbolically must be replaced by the controlled CAD/SOP values used in the study.

2. Geometry and test definition

The specimen is a flat beam with constant width and a documented thickness function $t(x)$. The controlled CAD file must define thin and thick ends, total span, width, thickness limits, coordinate origin and print orientation. The test SOP must define the contact or support location, manual load point and direction, loading sequence, maximum bend or stopping criterion, observation interval and recovery time.

The wedge geometry creates a non-uniform bending response. Because loading is manual and the support condition is not instrumented, the observed deformation or fracture location is interpreted empirically rather than calculated as a material property. Beam equations may describe an idealized case only after load, support and geometry are fully defined; they do not isolate modulus from an uncontrolled manual observation.

KEY INSIGHT

The Wedge Method becomes reviewable only when geometry, preparation, loading, observation and stopping rules are recorded. A photograph of a broken specimen without that context is not a reproducible result.

3. Provisional observation categories

Observation	Record	Permissible interpretation	Boundary
Abrupt fracture	Location, appearance, audible/visible events	Provisional brittle-like response under the SOP	No strength or toughness value
Fracture after deformation	Whitening, hinge, residual deformation, location	Provisional deforming-before-fracture response	No modulus or elongation value
No fracture at defined bend	Angle, force sequence, residual set	Provisional flexible response under the SOP	Does not define fatigue or creep
Large deformation with recovery	Angle, release time, recovery and damage	Provisional recovering response under the SOP	Does not define tear or cycle life

The observations support a provisional screening category under the defined protocol. Category assignment should be confirmed with instrumented testing when quantitative properties or design decisions are required. Mechanical envelopes must not be assigned to the visual categories without a traceable validation dataset.

A	B	C	D
Abrupt fracture Record location and surface appearance	Fracture after visible deformation Record whitening, hinge or other observations	No fracture in defined bend Record angle and residual deformation	Large deformation with recovery Record recovery after defined release time

Provisional categories under the defined protocol; no modulus, strength or toughness is assigned.

Figure 2. Provisional Wedge observation categories. They describe visible responses under the defined protocol and do not provide mechanical property values.

4. Controlled workflow

- Define the comparison question, retained reference and acceptance or investigation rule before printing.
- Use the controlled CAD and record resin, batch, additive identity and concentration, printer, orientation and exposure.
- Apply the defined cleaning, drying, post-cure and conditioning workflow. Do not compare specimens prepared differently unless preparation is the study variable.
- Perform the manual loading sequence at the recorded temperature and observe fracture, deformation and recovery without assigning calculated properties.
- Repeat using the prespecified specimen count and, where robustness matters, multiple operators.
- Advance selected conditions to the instrumented method linked to the intended property and application.

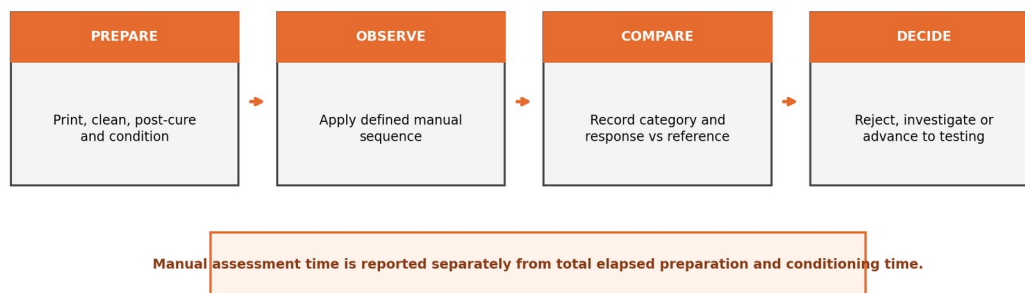


Figure 3. Controlled Wedge workflow. Hands-on assessment time and total elapsed preparation/conditioning time are reported separately.

5. Permissible applications

5.1 Formulation and process screening

Changes in Fine Tuner dosage may alter the observed Wedge response. Direction and magnitude are formulation- and process-specific and must be established experimentally. Fine Tuners should be described as photoaccelerants where that is their documented role. Fixed numerical shifts or universal optimum concentrations are not inferred from the Wedge observation.

5.2 Post-cure comparison

The Wedge response may be used to compare candidate post-cure conditions. Selection of a validated post-cure requires the relevant conversion, mechanical, dimensional, chemical and, where applicable, biological acceptance criteria for the intended use. The first visual match to a reference is not, by itself, a validated minimum post-cure.

5.3 Supplementary process monitoring

A Wedge specimen may serve as a supplementary process-control observation against a retained reference. It is not, by itself, a batch-release test. Batch acceptance must follow the applicable documented sampling plan, specifications, equipment control and out-of-specification procedure.

6. Interpretation and root-cause limits

Within a fixed material, print, post-cure, conditioning and operator protocol, fracture location may be recorded as a qualitative comparative response. A changed response can arise from material, mixing, printer, exposure, cleaning, post-cure, conditioning, geometry or operator variation. Root cause must be investigated; the Wedge observation alone does not identify it.

As-printed conversion and the effect of post-curing depend on formulation, exposure, geometry and measurement method. No universal degree-of-conversion range is assigned in this protocol. Quantitative conversion claims require the named analytical method, calculation, sampling position and controlled conditions.

7. Minimum validation before quantitative use

- Controlled SOP with dimensioned CAD, load application, rate, temperature, conditioning and stopping criterion.
- Replicate specimens per condition and multiple operators where inter-operator transfer is claimed.
- Repeatability and reproducibility analysis with prespecified category rules.
- Correlation against ISO 527 and any relevant fracture, impact, creep or fatigue method.
- Raw data for formulation, additive and post-cure comparisons.
- Blinded classification accuracy and a documented false-acceptance/false-rejection assessment for any release use.

8. Limitations

- Manual force and support conditions are not instrumented and can vary between operators.
- The result is geometry-, orientation-, cure-, temperature- and rate-dependent.
- Cross-resin comparison can conflate strength, modulus, ductility, defects, cure gradient, anisotropy and residual stress.
- Ageing, fatigue, creep, humidity, chemical resistance and tear require dedicated methods.
- The protocol does not replace ISO 527, certify a design, validate a medical device or release a batch by itself.

9. Conclusions

- The Wedge Method is a rapid qualitative comparative observation when performed under a controlled SOP.

- Fracture or bend location must not be converted into modulus, toughness or strength without independent instrumented validation.
- Manual assessment time is separate from total preparation, post-cure and conditioning time.
- The method can support candidate screening, post-cure comparison and supplementary process monitoring.
- Quantitative design, post-cure validation and batch release require their applicable instrumented evidence and control plan.

Revision note

Version 5.3 removes unsupported property, dosage-response, timing, post-cure and batch-release claims; defines geometry and loading information required by the SOP; labels category assignment as provisional; and separates manual assessment time from total elapsed workflow time.

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Disclosure. Dr. Juan Seguro is founder and Scientific Director of 3Dresyns by Resyner Technologies S.L., the producer of the materials, Fine Tuners and screening tools discussed. The Wedge Method is an internal qualitative screening protocol and does not replace application-specific characterization.

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