EPOC CRAFTER

Flexural Modulus Test & Plastic Part Deflection Validation Toolkit

Engineering Guide | ASTM D790-25 / ISO 178:2019

A practical, evidence-first workflow linking material identification, three-point bending data, specimen modulus, simplified structural screening, functional displacement limits and signed part validation.

Use this guide with the 13-tab Validation Workbook and separate Test & Approval Checklist. All calculations are screening or data-reduction aids; they do not demonstrate compliance with any standard by themselves.

Document control	Information
Revision	1.0 | 20 November 2026
Applicability	Rectangular plastic specimens; conventional three-point bending; conditional small-deflection rectangular beam model
Reference article	Flexural Modulus of Plastics: Formula, Testing and Design Use
Evidence rule	No fabricated raw test data; no unapproved materials database values.

01 / WORKFLOW

Quick start and decision workflow

The workbook separates coupon data analysis from finished-part design verification. Keep each evidence record and its source linked to the controlled project.

Stage	Excel tab	Exit requirement
01 Define functional need	02 Requirements	Service force, time, environment, allowable deflection and a controlled requirement source.
02 Identify material	03 Material Data	Commercial grade, lot, reinforcement/temper where relevant, TDS/test report revision and source.
03 Identify test method	04 Test Setup	Actual standard, procedure, geometry, orientation, rate, deflection technique and correction evidence.
04 Analyze specimen curve	05-06 Raw/Calculation	Real corrected midspan deflection and force; interval or initial tangent evidence.
05 Assess scatter	07 Statistics	Independent specimens and descriptive statistics; no inferred tests.
06 Compare candidates	08 Comparison	Equivalent test definitions and environmental conditions.
07 Screen geometry	09-10 Beam/Sensitivity	Declared ideal beam model; linear behavior and contacts checked.
08 Verify actual part	11-12 Verification/Dashboard	Real measurement record, authorized reviewer and signed decision.

A low predicted displacement is not a product PASS. Requirements, method validity, model applicability and measured part evidence are separate gates.

02 / MATERIAL TRACEABILITY

Material identity and traceability

Never compare a polymer family name against a commercial grade with no context. The property source must describe the actual processed and conditioned material under evaluation.

Field	Minimum record	Reason
Material identity	Trade grade, resin, manufacturer and additive/reinforcement mass fraction if given	Different variants can have materially different flexural behavior.
Manufacturing	Molded flow direction, extrusion direction or print orientation	Processing creates texture, skin layers or anisotropy.
Batch trace	Batch/lot and document revision	Permits supplier evidence backtracking.
Test source	Lab/report ID, test date, test method edition, equipment	Prevents a datasheet number from being treated as a measured part result.
Environment	Temperature, humidity, conditioning and duration	Viscoelastic and hygroscopic effects can change stiffness.
Modulus identity	Initial tangent / declared chord / ISO interval / secant	Methods and calculation points are not interchangeable.

A nominal 3,000 MPa from a vendor datasheet is not enough to predict the displacement of a bracket. Start with specimen and reporting context; check actual structure, loading and service conditions.

Do not mark a value Verified when only a marketing table is available. An independently reviewed data sheet may support screening; laboratory traceability and part approval remain separate.

03 / ASTM TEST METHOD

ASTM D790-25: what the workbook supports

ASTM D790-25 is identified by ASTM International as the active three-point flexural test-method edition. The official scope covers unreinforced and reinforced plastics and electrical insulating materials; the full controlled standard and relevant material specification govern test execution.

Item	Applied approach / requirement
Fixture	Simply supported rectangular specimen loaded at midspan; record actual support centers and nose/support radii.
Common molded-specimen reference	127 x 12.7 x 3.2 mm specimen; nominal 16:1 span-to-depth for applicable common cases. This does not imply a 127 mm support span.
Procedure A/B	Nominal outer-fiber strain rates 0.01 and 0.10 min-1 respectively under their procedure conditions. Check specimen-specific requirement.
Crosshead rate	R = Z L^2 / (6d) mm/min; input actual specimen span L, thickness d and declared Z.
Initial tangent modulus	E = L^3 m / (4bd^3) where m is the initial straight-line force-versus-midspan-deflection slope (N/mm).
Chord modulus	E = (sigma2 - sigma1) / (epsilon2 - epsilon1); report both selected points and source.
Deflection method	Report whether crosshead movement or independent deflectometer is used, with relevant compliance/accuracy review.

The workbook does not automatically guess the ASTM initial tangent region. Enter a lab-approved initial slope and analysis evidence ID in 04 Test Setup; 06 Calculation then performs dimensional conversion.

04 / ISO TEST METHOD

ISO 178:2019: fixed modulus interval

ISO 178:2019 is listed as the published sixth edition by ISO at the date of this document. ISO/DIS 178 is a revision draft, not the published edition. ISO 178 covers relevant rigid and semi-rigid plastics in specified test conditions.

Parameter	Workbook interpretation
Nominal lower strain	epsilon1 = 0.0005 (0.05%).
Nominal upper strain	epsilon2 = 0.0025 (0.25%).
Modulus	Ef = (sigma2 - sigma1)/(0.0025 - 0.0005), using applicable interval treatment.
Common specimen	Preferred example 80 x 10 x 4 mm; typical support span 64 mm, subject to applicable provisions.
Deflection at epsilon1	D = epsilon L^2/(6d); for L = 64 and d = 4, D1 approximately 0.08533 mm.
Deflection at epsilon2	D2 approximately 0.42667 mm for the same geometry.
Input curve	Use corrected/qualified midspan displacement and a force trace covering both strain points.

The workbook interpolates stress values between consecutive curve readings surrounding these two strain targets. A missing bracket, non-increasing displacement trace or invalid geometry blocks the calculation. For test compliance, the user must still confirm full procedural requirements of the licensed standard.

ISO notes that material test results are not directly transferable to engineering design parameters. A separate part model and in-service verification remain essential.

05 / GEOMETRY & EQUATIONS

Three-point bending geometry and equations

Conventional small-deflection Euler-Bernoulli beam relationships are used for rectangular, simply supported coupons with center force. N and mm inputs produce MPa for stress and modulus.

Symbol	Physical quantity	Unit
F	Center loading force	N
L	Actual support span between centers	mm
b	Measured specimen width	mm
d	Measured specimen depth / thickness	mm
D	Qualified midspan specimen deflection	mm
sigma_f	Nominal outer-surface flexural stress = 3FL/(2bd^2)	MPa
epsilon_f	Nominal outer-surface strain = 6Dd/L^2	dimensionless
m	Initial tangent slope of F versus D	N/mm
E	Flexural modulus	MPa

Thickness is cubed in the initial tangent expression. A 1% thickness input change can shift calculated modulus by approximately 3%, holding other quantities fixed. Consequently, dimension inputs must be specimen-specific, not merely nominal drawing sizes.

Not applicable as written to four-point bending, arbitrary cross-sections, highly anisotropic laminate behavior, large deflections or uncorrected fixture/compliance effects.

06 / DATA QUALITY

Test rate, deflection measurement and environment

Risk	Record and action
Test rate	Record nominal Z, calculated machine speed and actual executed speed; identify ASTM procedure or ISO segment.
Machine compliance	Confirm independent midspan deflection or the appropriate documented correction. Machine crosshead travel can include frame/fixture movement.
Seating / contact	Check initial curve seating, local indentation and loading-nose support position without changing true material curvature.
Conditioning	Record humidity, drying, immersion state, conditioned time and temperature; reference applicable material standard.
Anisotropy	Identify melt-flow / print orientation / ply direction, separately from specimen dimension.
Geometry and shear	Evaluate specimen span-to-depth and transverse shear. Highly orthotropic laminates may need special method or span.
Calibration	Retain load-cell, displacement sensor, contact fixture and instrument calibration identifiers.

Data-entry rule: all force observations in N, corrected specimen-center deflection in mm, strain as fraction (0.0025 = 0.25%), and E in MPa. Do not enter a percent number as a fractional strain.

Any failure of instrument validity, correction method or test geometry prevents a credible method-compliant result even if a spreadsheet formula returns a number.

07 / CURVE CALCULATION

Raw force-displacement data reduction

Sheet 05 accepts up to 100 ascending-force/deflection readings for one specimen. Paste true observed force and qualified midspan deflection values; no fabricated curve is supplied.

Action	Expected result / restriction
01 Enter specimen setup	L, b, d > 0; exact method edition and target interval.
02 Enter raw measurements	B = force in N; C = midspan D in mm; D = time in s.
03 Calculate strain and stress	E = 6Dd/L^2; F = 3FL/(2bd^2).
04 Check ordering	Negative entries and decreasing deflection create a data-error status; duplicate or incomplete rows also need review.
05 Bracket selected points	Curve must encompass both modulus strain points.
06 Interpolate stresses	Linear interpolation between the two neighboring measured curve points at each target strain.
07 Calculate interval modulus	Divide sigma2 - sigma1 by epsilon2 - epsilon1.
08 Audit original file	Inspect raw trace, separation, resolution, compliance and method-specific analysis method.

For ASTM initial tangent, a blind maximum slope from noisy curve segments would be inappropriate. The workbook instead accepts an independently approved initial linear F-D slope and its region/evidence reference, then calculates E = L^3 m/(4bd^3).

One raw curve is one specimen only. Reported repeat count cannot be greater than the number of independently obtained and reviewed specimen results.

08 / MATERIAL COMPARISON

Statistics and comparability

For independent coupon results E1 ... En, report count, arithmetic mean, sample standard deviation, coefficient of variation, minimum and maximum. Do not invent results to satisfy a sample count.

Metric	Definition / evidence
Mean	SUM(Ei)/n (MPa).
Sample SD	sqrt[SUM((Ei - mean)^2)/(n - 1)] when n >= 2.
CV (%)	100 x SD/mean when the positive mean is defined.
Required count	Project- or standard-specific count recorded separately; no universal substitute guessed in this toolkit.
Comparison gate	Match grade/filler, method edition, modulus definition, direction, temperature, conditioning and deflection technique.
Approval input	Actual lab reports and data validity checks; a low CV alone does not prove conformity.

Worksheet 08 compares three candidate materials side by side; a matching metadata check only means the listed fields are aligned. It does not establish identical strain histories, specimen preparation, machine corrections or end-use behavior.

ASTM tangent and ISO interval values must not be pooled into one unconditional ranking. Do not treat a larger modulus as proof of higher flexural strength or more durable service.

09 / STRUCTURAL SCREENING

Simple beam deflection: accepted model only

This module screens a uniform rectangular beam, simply supported at two points and subjected to one centered transverse load, assuming short-time linear elastic material behavior and small deflection.

Output	Equation
Second moment of area	I = b d^3 / 12 [mm^4]
Bending rigidity	EI = E I [N mm^2]
Midspan deflection	delta = F L^3 / (48 E I) [mm]
Nominal bending stress	sigma = 3 F L / (2 b d^2) [MPa]
Nominal surface strain	epsilon = 6 delta d / L^2 [-]
Calculated screen	delta compared with controlled project limit [mm].

The modulus for service screening must reflect relevant loading rate, material direction, temperature, duration and strain. A laboratory ISO/ASTM modulus measured under a narrow initial strain interval need not apply unchanged at a much higher service strain.

Do NOT use the model for arbitrary plates, joints, ribs, holes, concentrated contact deformation, large deflection, nonlinear response, creep/fatigue or anisotropic layups without an independent engineering model.

10 / DESIGN SENSITIVITY

Thickness and modulus sensitivity

For the same simply supported beam, central load, span and fixed width, bending inertia varies as d^3. Therefore modeled displacement varies inversely as thickness cubed when all other model assumptions are unchanged.

Parameter change	Ideal-model effect	Caution
Thickness ratio k	Inew / Iref = k^3; delta_new / delta_ref = 1/k^3.	Does not include warpage, sinks, molded skin changes, dimensional tolerances or contact.
Modulus ratio k	delta_new / delta_ref = 1/k.	Material E may depend on temperature, speed, reinforcement orientation and service time.
Span ratio k	delta_new / delta_ref = k^3.	Changing supports can also change contact and load path.
Load ratio k	delta_new / delta_ref = k.	Only within linear elastic regime.

Workbook 10 shows thickness factors 0.75 / 0.90 / 1.00 / 1.10 / 1.25 and modulus factors 0.80 / 0.90 / 1.00 / 1.10 / 1.20. These are mathematical sensitivity scenarios, not tolerance distributions or statistical confidence limits.

The geometric sensitivity sweep does not replace molded-wall-thickness DFM rules, moldflow prediction, finite-element contact analysis or service verification.

11 / WORKED EXAMPLE

Worked article case: Delrin 500P guide plate

This illustration reproduces the numerical scenario published in the linked EPOC CRAFTER article. Original signed force-deflection traces and the material-lot certificate are not supplied in the pack and are not implied by the example.

Input / output	Article case value
Material	Delrin 500P NC010, unfilled molded POM; anonymized lot.
Test method and direction	ISO 178:2019; molded flow direction; approximately 23 C.
5 reported coupon moduli [MPa]	2,950 / 3,010 / 2,990 / 3,030 / 3,020.
Mean / sample SD	3,000 MPa / 31.6 MPa.
Simplified beam geometry	b = 10 mm, d = 4 mm, L = 64 mm; centered F = 30 N.
I and EI	53.333 mm^4 and 160,000 N mm^2.
Predicted midspan displacement	1.024 mm vs project screening limit 1.20 mm.
Nominal bending stress	18.0 MPa (not the local contact stress).
Predicted nominal surface strain	0.0060 = 0.60%.

CRITICAL: The predicted 0.60% surface strain exceeds the 0.25% upper strain used for the ISO modulus interval. The 1.024 mm predicted displacement is an extrapolated short-time screening result, not a verified structural PASS.

12 / ACCEPTANCE AND SIGN-OFF

Evidence, verification and approval

Finish at the part rather than the coupon. A structural calculation and a laboratory coupon test cannot by themselves establish actual assembly behavior or production acceptance.

Gate	Required documented check
Specification	Drawing revision, functional displacement criterion, load and duration.
Material	Commercial grade, source/lot, reinforcement state, process and orientation.
Lab test	Actual standard edition, verified test record, environmental and measurement metadata.
Calculation	Reproducible formulas, units, geometry and declared modulus definition.
Model applicability	Supports, contact, small-deflection, operating strain, time, temperature and load path.
Part inspection	Actual measured part deflection under the specified load and conditions; calibrated instruments.
Reviewer signature	Named reviewer, date, disposition and evidence/report ID.

The workbook uses administrative statuses such as INCOMPLETE, SCREENING ONLY, PENDING PART VALIDATION and REVIEWED PASS. The last requires manually entered evidence, matched conditions, signed decision reference and reviewer.

A spreadsheet cannot certify ASTM/ISO procedural compliance, material authenticity, structural integrity or regulatory approval. These are external engineering and quality-system responsibilities.

13 / STOP RULES

Known error modes and stop rules

Observed issue	Required response
0 or negative dimensions	Stop. Confirm measured specimen geometry and unit system.
Different method definition	Do not pool or rank modulus values without harmonized test basis.
No raw curve bracketing targets	Interval modulus is undefined; collect more qualified data.
Wrong ordinate	Crosshead movement may not equal specimen midspan deflection; review correction.
Curve reversal / discontinuity	Stop interpolation; review raw machine trace and data acquisition.
Unidentified ASTM tangent region	Do not infer tangent from a noisy maximum local slope. Require approved analysis.
One specimen represented as five	Reject statistical summary; obtain independent specimen records.
Material E substituted for Young's E	Require justified constitutive/FEA modeling parameters.
Prediction beyond test strain window	Label extrapolation; verify nonlinear material / real part.
Measured part displacement exceeds limit	Reject or perform documented engineering disposition, never auto-approve.

Mandatory review is stronger than an automatic green screen. Unexpected data are reasons to inspect the physical test, equipment and applicable standard, not to tune formulas until a preferred answer appears.

14 / REFERENCE CONTROL

Standards and scope record

The following identifiers and technical source descriptions were checked against standards-publisher and instrument-manufacturer public information on 20 November 2026. No non-EPOC-CRAFTER external hyperlinks are embedded in this resource.

Reference	Controlled use in this toolkit
ASTM D790-25	Three-point flexural test method for plastics; initial tangent, selected chord and secant definitions; test reporting and method limits.
ISO 178:2019	Published sixth edition; three-point rigid/semi-rigid plastics flexure; nominal 0.05%-0.25% modulus interval.
ISO/DIS 178	Revision draft under development, explicitly NOT treated as a published replacement for ISO 178:2019.
Instron ASTM D790 application guidance	Crosshead rate, measurement types, example geometry and significance of compliance.
EPOC CRAFTER: Flexural Modulus of Plastics	Published calculations and POM guide-plate illustration, not an original raw-laboratory dataset.

Applicability exclusions: four-point tests, sandwich structures, cellular materials, complex composite laminates, unverified nonlinear constitutive models, creep/fatigue lifetime and regulatory certifications. For production tests, always consult the full current purchased standard and material-specific specifications.

Resource version 1.0 | 20 November 2026. Source citations are bibliographic identifiers, not clickable third-party links. RFQ and home links in this file point only to epocrafter.com.