Bulk Modulus Data Verification Checklist

Fillable engineering review form | Materials + hydrostatic response + FEA

PURPOSE

Qualify the material identity, provenance and applicable loading conditions before a calculated or measured bulk modulus is used in a design or FEA material model.

REVIEW SEQUENCE

01 Define material/lot and service conditions.

02 Distinguish measured, derived and reference K data.

03 Verify constitutive model and solver setup.

04 Set project acceptance criteria before comparing with physical evidence.

USE WITH EXCEL WORKBOOKS

Bulk Modulus and Elastic Constants Calculator.xlsx

Poisson Ratio Sensitivity and FEA Validation.xlsx

STOP CONDITIONS

No grade/lot traceability where lot-specific qualification is required.

E and Poisson ratio from incompatible states or loading rates.

Isotropic model assumed for directional or strongly nonlinear data.

Missing test evidence, acceptance limit or engineering approval.

This document is a structured review aid, not a substitute for calibrated testing or engineer approval.

A. Project and Material Identification

Complete each field; example or catalog values do not establish material identity.

Project / purchase order ID

Part number / drawing revision

Engineer / review owner

Review date (YYYY-MM-DD)

Material supplier / manufacturer

Exact commercial material grade

Batch / lot / heat / coil ID

Stock / product form

Temper / anneal / moisture / aging state

Manufacturing method / build direction

Service temp / humidity / exposure

Pressure loading and critical function

CHECK GATES

- ☐ Material designation and physical form unambiguous
- ☐ Lot/state matches the property source
- ☐ Loading and service conditions documented

B. Data Provenance and Elastic Properties

Distinguish measured hydrostatic data from inferred isotropic linear-elastic parameters.

Data source / manufacturer

Source document and revision

Test standard and version / protocol

Raw record / report reference

Young modulus E (MPa)

Poisson ratio nu (unitless)

Bulk modulus K (MPa)

Shear modulus G (MPa)

K origin: MEASURED / DERIVED / REF

Uncertainty / CI and test count

DO NOT TREAT ANY AXIAL COMPRESSION VALUE AS A DIRECT K MEASUREMENT.

- [ ] E and nu from compatible source/temperature/state
- [ ] Mathematical stability and unit checks completed
- [ ] Source uncertainty and effective strain range reviewed

C. Test State and Measurement Method

Record the physical method, instrument calibration and strain/pressure range.

Hydrostatic pressure interval / MPa

Volume method, V0/V1 and units

Stress state: hydrostatic / uniaxial / other

Specimen + environment temperature

Humidity / moisture conditioning

Load rate / dwell / time history

Specimen orientation / anisotropy

Specimen geometry and dimensions

Instrumentation and calibration ID

Replicates / scatter / uncertainty

Original raw data reference

Defined method / lab approval

- [ ] Compression method matches property being claimed
- [ ] Raw p-V data available, not just a copied K number

D. Constitutive and Numerical Consistency

Positive modulus and -1 < nu < 0.5 are model-specific elastic stability conditions.

- [ ] Homogeneous and isotropic approximation justified
- [ ] Small strain and linear elastic range demonstrated
- [ ] Temperature / rate / moisture states compatible
- [ ] E, G, K, nu use compatible units and definitions
- [ ] Derived K explicitly labeled, not called measured
- [ ] Near-nu=0.5 sensitivity tested with realistic uncertainty
- [ ] If anisotropic, use full tensor or approved directional model
- [ ] If rubber/foam, use qualified nonlinear model and test data
- [ ] If time dependent, include appropriate relaxation/creep response
- [ ] Limits of volumetric-pressure approximation documented

ENGINEERING RELATIONSHIPS (ISOTROPIC LINEAR ELASTIC ONLY)

$K = E / [3(1 - 2\nu)]$ $G = E / [2(1 + \nu)]$

$\beta = 1/K$ volumetric strain $= -dp/K$

K from pressure-volume data is a secant estimate over a specified interval.

E. FEA Input and Solver Checklist

Check analysis type, element formulation, model data and the physical load path.

- [ ] FEA material name corresponds to certified material ID
- [ ] Material orientation and anisotropy correctly represented
- [ ] Units, E, nu, K, G and density separately verified
- [ ] Solver / release / element type recorded
- [ ] Near-incompressible formulation considered if needed
- [ ] Contact, restraints and pressure region physically correct
- [ ] Geometric nonlinear effects reviewed if required
- [ ] Mesh sensitivity checked for critical quantities
- [ ] Load cases and service temperature enveloped
- [ ] Appropriate plasticity/creep/large-strain model if needed
- [ ] Independent hand calculation / benchmark completed
- [ ] Real measurement, test uncertainty and tolerance available
- [ ] Function-driven dimension/deflection acceptance checked
- [ ] Failure mechanisms evaluated beyond material bulk modulus

IMPORTANT: K controls volume response, not component yield, fracture or contact failure.

F. Independent Correlation and Acceptance

Missing physical evidence or missing limit means NEEDS REVIEW, not PASS.

Solver/model file ID and version

Test record and measurement basis

Measured response (strain, dimension, etc.)

Quantity units and sign convention

FEA predicted response

Independent measured response

Absolute or relative difference

Project-specific allowable difference

Measurement uncertainty / repeatability

Acceptance rationale / limit source

- [ ] Correlation uses identical geometry, pressure, support and output definitions
- [ ] Instrument, calibration and test raw records traceable
- [ ] Acceptable limits were specified before reviewing outcome
- [ ] No apparent PASS assigned to missing or illustrative evidence

G. Closure, Disposition and Signoff

Only the authorized reviewer can release a material dataset or FEA material model.

Disposition: APPROVE / REJECT / HOLD

Qualified reviewer and role

Signature / controlled approval ID

Approval date

Approved material record revision

Approved solver/material model reference

Open deviation or NCR ID

Material / inspection requirements for RFQ

RELEASE GATES

- [ ] Material grade, lot, condition and source are reconciled
- [ ] All required test evidence and uncertainty are available
- [ ] Applicable constitutive model and FEA approach supported
- [ ] All hard acceptance limits are satisfied with evidence
- [ ] Outstanding discrepancies have approved disposition

THE WORKSHEET CANNOT ISSUE AN AUTOMATIC ENGINEERING APPROVAL.