

CAE Pre-Processing & Geometry Standardization Guide

1. Welcome & Introduction

Welcome to the KEYAN Calculation Technical Support Portal. This onboarding guide is designed to establish a standardized pre-processing framework for global engineering teams. In high-fidelity numerical analysis—such as transient thermal-structural coupled simulations, non-linear structural mechanics, and multi-scale fluid dynamics—the fidelity of your finite element model dictates both solution convergence and real-world accuracy.

By adhering to the geometric clean-up, meshing quality controls, and material characterization protocols defined in this document, you ensure that your CAD data transforms seamlessly into highly robust, production-ready simulation pipelines, minimizing solver errors and computational overhead.

2. CAD & Geometry Preparation Manual

Raw production CAD data often contains complex design details necessary for manufacturing but detrimental to finite element analysis (FEA). Geometry cleanup must be systematically performed prior to meshing.

- **Interference & Clearance Resolution:** All overlapping geometries and body interferences must be eliminated. Contact surfaces must align precisely to prevent localized artificial stiffening or non-convergence during contact initialization.
- **Defeaturing (Feature Defeaturing):** Non-critical design details—such as cosmetic fillets, tiny chamfers, stampings, product logos, and minor holes ($< 3\times$ average element size) that reside outside high-stress zones—must be suppressed or removed. This drastically improves cell quality and prevents localized element distortion.
- **Mid-Surface Extraction:** For thin-walled structures and complex sheet metal enclosures, mid-surface extraction is mandatory. Solid parts must be converted to 2D shell surfaces with accurate thickness attributes assigned, changing a costly 3D solid mesh into a high-efficiency 2D shell mesh layout.
- **Shared Topology / Imprinted Edges:** Ensure parts within an assembly use Shared Topology (or co-nodes) where appropriate. For regions involving localized moving loads

(e.g., a welding arc tracking path), edges must be pre-imprinted onto the face to provide precise node tracking along the trajectory.

3. Meshing Quality & Discretization Standards

Mesh generation must balance numerical resolution with computational economy. High-order (second-order) elements should always be selected for non-linear, thermal, and stress concentration analyses.

Component/Structure	Recommended Element Type	Target Global Size	Mesh Quality Thresholds
Regular / Prismatic Sub-structures	2nd-Order Hexahedral (Hex20)	3.0 mm – 5.0 mm	Jacobian > 0.7 Aspect Ratio < 5:1
Complex / Non-prismatic Fittings	2nd-Order Tetrahedral (Tet10)	8.0 mm – 10.0 mm	Skewness < 0.6 Orthogonal Quality > 0.4
Thin-walled Sheet Metal Enclosures	2nd-Order Shell (Quad8 / Tria6)	Scale with thickness	Warping Factor < 0.1 Aspect Ratio < 3:1
Heat Affected Zones (HAZ) & Welds	Finely Graded Mixed Hex/Tet	1.0 mm – 1.5 mm local	Grading Rate < 1.2 Smooth transition required

4. Material Characterization Requirements

For linear static runs, isotropic structural properties (Elastic Modulus, Poisson's Ratio, Density) suffice. However, for high-temperature engineering such as CO2 welding analysis, material non-linearity is mandatory.

- **Temperature-Dependent Properties:** Users must define Thermal Conductivity, Specific Heat, and Thermal Expansion Coefficient as functions of temperature across a range scaling up to the material's melting point (e.g., 0°C to 1500°C+).
- **Non-linear Plasticity Models:** To capture residual stresses and permanent thermal deformations accurately, temperature-dependent yield strength curves and hardening models (e.g., Bilinear/Multilinear Kinematic Hardening) must be populated in the material system.

TECHNICAL SUPPORT NOTE: Compliance with this pre-processing standard reduces solver convergence failures by up to 45% and ensures compatibility with KEYAN Calculation automated

review workflows. If your assembly deviates from these criteria, please contact support@keyan-calculation.com before executing solutions.