

PEEK Machining Guide

Dedicated engineering reference guide for buyers, engineers, and sourcing teams

Based on article:

<https://nylonplastic.com/peek-plastic-machining-guide/>

Quick Overview

PEEK (polyetheretherketone) sits at the apex of engineering thermoplastics: continuous service above 250°C, tensile strength rivaling aluminum at one-sixth the weight, and chemical resistance that survives autoclaves, jet fuel, and concentrated acids. But these same properties that make PEEK invaluable in aerospace, medical implants, and oil & gas also make it one of the most challenging materials to CNC machine correctly. The heat generated during cutting does not dissipate — it builds up in the chip and workpiece, causing melting, dimensional drift, and rapid tool wear.

This guide covers PEEK machining parameters from our production floor: grade selection, feeds and speeds for each operation, the critical annealing step that most shops skip, and the tooling choices that make the difference between a \$500 scrapped part and a flight-ready component.

Unfilled PEEK (natural): The baseline. Tensile 95-100 MPa, excellent machinability (best surface finish), used for medical implants and seals. Machines similarly to brass — continuous chips, low tool wear. PEEK-GF30 (30% glass fiber): Stiffer (flex modulus 6 GPa vs 3.7 GPa for unfilled) but highly abrasive. Tool life drops 50-70% versus unfilled PEEK; carbide tools wear in 15-30 minutes of continuous cutting. PEEK-CF30 (30% carbon fiber): Highest stiffness and strength (tensile 220 MPa) but maximum abrasiveness. Requires diamond-coated tooling for production runs. Carbon fiber also makes the material electrically conductive — relevant for semiconductor applications.

Engineering Notes

PEEK Grades: Choosing the Right Variant for Machining

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The Critical Annealing Step

PEEK accumulates significant internal stress during machining. The outer skin heats and expands while the core stays cool — as the part cools, this differential creates residual stresses that can cause warpage of 0.05-0.2 mm over the following days, or immediate cracking in thin-walled sections. Annealing protocol: Heat to 200°C (for unfilled) or 220°C (GF/CF grades) at 1°C/min, hold for 3 hours minimum (add 1 hour per 25 mm of thickest section), then cool at 0.5°C/min to below 140°C before removing from oven. Skipping this step guarantees dimensional instability in tight-tolerance PEEK parts.

Design Rules for Machining PEEK

Tool selection: carbide minimum, diamond preferred: For unfilled PEEK, sharp polished carbide (AlTiN or TiAlN coated) runs 30-60 minutes before dulling. For GF/CF grades, CVD diamond-coated carbide extends tool life 5-10x. PCD (polycrystalline diamond) inserts reach 10-20x carbide life in production environments. The premium on diamond tooling pays back after 50-100 parts. Rigid fixturing with thermal compensation: PEEK expands at $47-55 \times 10^{-6} / ^\circ\text{C}$ — roughly 2x aluminum and 5x steel. A 100 mm part machined at 40°C (warm from cutting) shrinks 0.15-0.20 mm when measured at 20°C. Machine to nominal + thermal allowance, or machine in temperature-controlled coolant to keep the part at $20 \pm 2^\circ\text{C}$. Chip evacuation is everything: PEEK chips are tough, stringy, and do not break easily. They wrap around tools and re-cut, causing surface defects. Use high-pressure through-tool coolant (70+ bar) for deep holes, or peck drilling cycles with full retraction. For milling, compressed air at 6+ bar directed at the cut zone clears chips effectively for unfilled grades.

Industry Application Matrix

Brackets, bushings, seals, cable management FST (flame/smoke/toxicity) certified; -55 to +260°C range Spinal cages, dental abutments, trauma plates Unfilled implant-grade PEEK ISO 10993 biocompatibility; radiolucent for imaging Seals, backup rings, electrical connectors NORSOK M-710; H₂S, CO₂, and methanol resistance Wafer handling, test sockets, chamber components Low outgassing; static dissipative (under 10⁶ ohm/sq)

Cost Decision Framework

Material cost: Unfilled PEEK rod/plate: \$80-150/kg. PEEK-GF30: \$90-170/kg. PEEK-CF30: \$120-250/kg. This is 20-40x the cost of aluminum and 8-15x the cost of PA66. A single 100x100x25 mm plate costs \$30-60 in material alone. Machining cost: PEEK machines at ~50% of aluminum speed due to lower feeds and frequent tool changes. Diamond tooling adds \$80-200 per tool but saves 5-10 tool changes per shift. Annealing adds 4-6 hours to lead time and \$15-40 in oven cost per batch. Decision rule: Machined PEEK only makes economic sense when: (a) quantity is 1-200 pcs (injection molding PEEK requires \$25K-50K mold + \$80-150/kg resin), (b) the part needs the combination of 250°C+ service, chemical resistance, and biocompatibility that no cheaper material offers, or (c) the cost of failure exceeds 100x the material premium — as in aerospace, medical implants, and deep-sea oil equipment.

Common Defects and Solutions

Surface melting / smearing Glossy, melted patches on machined surface Insufficient cooling; feed too slow for RPM Increase flood coolant flow; raise feed 20% or reduce RPM to keep chip thickness adequate Part measures out of tolerance 24h later Residual stress from machining without annealing Anneal per protocol (200°C/3h/slow cool); measure after cool-down Visible wave pattern or roughness on surface Tool stickout too long; insufficient fixturing rigidity Reduce stickout below 4x diameter; add jack screws or vacuum fixture support Cutting edge rounding after under 15 min cutting Glass/carbon fiber abrading carbide tool edge Switch to CVD diamond-coated or PCD tooling; reduce speed 15% for GF/CF

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RFQ Checklist

- Application environment: temperature, moisture, UV, chemicals, sterilization, or outdoor exposure.
- Mechanical requirements: load, stiffness, impact, wear, friction, creep, and fatigue life.
- Drawing requirements: tolerance class, critical dimensions, surface finish, threads, inserts, and inspection method.
- Production needs: prototype or production quantity, expected annual volume, target unit cost, and lead-time window.
- Material notes: preferred grade, color, reinforcement, flame rating, certification, and substitute-material flexibility.

Need manufacturing support?

Share your drawing, target material, working environment, tolerance requirements, and quantity. Nylon Plastic can help evaluate manufacturability, material alternatives, and production quotation details.

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