PrintKinetic RESOURCE

Material Behavior Field Guide

https://printkinetic.com/resources/material-behavior-field-guide/ · Last updated 2026-09-08

Every filament family gets marketed with a small set of headline numbers: tensile strength, a print temperature range, maybe a heat-deflection figure. Those numbers are real, but they describe the material in isolation, not the part you are actually about to make. The material question that matters is narrower: given the specific exposure this part will see and the role it plays, does this filament hold up, and does it hold up consistently rather than in a best-case lab condition. That is the question the Material Fit Selector is built to answer, and it is the same question this guide keeps returning to across heat, moisture, UV, and chemical exposure.

Heat is the exposure most often underestimated. A filament's glass transition temperature, not its print temperature, determines when a printed part starts to soften and creep under its own load, and that threshold can sit well below a room that gets warm in direct sunlight or near a heat source. PLA is the clearest example: it prints easily and looks great on a shelf, but it is a poor choice for anything that sits in a hot car or near a window in summer. The Heat Exposure Material Screen exists because "it printed fine" and "it survives its actual environment" are two different claims, and only the second one protects the part's function.

Moisture behaves differently from heat because it is invisible until it isn't. Nylon and PETG are hygroscopic: they pull ambient humidity into the filament itself, and a spool that was bone dry when opened can degrade within days in a humid shop. Wet filament does not just print worse cosmetically. It causes steam pockets inside the nozzle that show up as popping sounds, brittle layers, and a weaker part that looks fine until it is loaded. The Drying Need Triage engine treats drying as a print-day decision tied to the specific filament, storage history, and ambient humidity, not a one-time step you can assume stays done.

UV and outdoor exposure add a slower failure mode that is easy to ignore because it takes weeks or months to show up. Sunlight breaks down polymer chains through photodegradation, which shows up first as surface chalking and color fade, then as brittleness that was never visible in an indoor test print. A part that looks structurally sound after printing can still be a poor outdoor choice if its base polymer has no UV stabilization. The UV and Outdoor Material Screen separates filaments with genuine outdoor tolerance

from ones that merely survive a short test window, because the honest failure timeline is measured in seasons, not days.

Chemical exposure and layer-boundary weakness round out the picture, and they interact with everything above. A part exposed to a solvent, oil, or cleaning agent can fail along its layer lines specifically, even when the bulk material would tolerate that chemical fine in solid form, because the layer boundary is already the mechanically weakest plane in an FDM part. That is why the Layer Separation Triage engine exists as a companion to material selection rather than a separate topic: a material that is chemically appropriate can still delaminate if the print itself has weak interlayer bonding, and a material choice alone cannot fix a bonding problem.

Consider a bracket meant to hold a small solar-powered sensor to an outdoor railing. Printed in standard PLA because it was on hand and printed cleanly, the bracket looks finished and strong on day one. Within a few weeks of direct sun and summer heat, it has started to soften on warm afternoons and gone visibly chalky and brittle at the edges, and by the end of the season it snaps under a load it easily held when new. The Material Fit Selector would have flagged PLA's low heat-deflection temperature and weak UV tolerance against an outdoor, sun-exposed role before the first layer printed; the UV and Outdoor Material Screen exists for exactly this case, where a material choice that looked fine in the shop fails predictably once its real environment is accounted for.

A common mistake is treating material selection as a one-time decision made before the first layer prints. In practice, the exposure a part will see, the humidity it was printed in, and the interlayer bonding it achieved are three separate variables that each need checking, and a good decision addresses all three rather than assuming a "strong" filament covers every risk. Use the engines above together: pick the material for the exposure, confirm it was dried for the print, and confirm the print itself bonded well enough to trust under that exposure.

FAQ

Is there one filament that is best for every part?

No. The right material depends on the exposure the part will actually see (heat, moisture, UV, chemicals) and the role it plays, not a single strength number on a spec sheet.

Does a dry filament print stay dry?

Not indefinitely. Hygroscopic filaments like nylon and PETG re-absorb ambient moisture once opened, so drying is a print-day decision, not a one-time step.