What is carbon buildup in a nozzle?

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Abstract. Burnt plastic from filament left in a hot nozzle. Marlin's optional idle timeout cuts the heater after 5 minutes; Prusa brushes the outside at 250 °C.

Keywords: pla, abs, polycarbonate, nylon

1 What is carbon buildup in a nozzle?

Carbon buildup is filament that has burnt inside or on the nozzle. Polymaker says plastic left too long in a hot nozzle oxidizes into burnt residue that narrows the flow path until it clogs. A hot then cold pull removes it from the inside; Prusa brushes the outside after 3 to 5 minutes at 250 °C.

1.1 The number

Table 1. The number

What	Value	Source
Marlin idle timeout	Heater off after 5 minutes without extruder movement, armed above 180 °C; nozzle and bed set to 0 °C. Off in the stock configuration file	Marlin `HOTEND_IDLE_TIMEOUT`
Klipper idle timeout	Heaters and motors off after 600 seconds idle; on by default	Klipper documentation
Prusa MK3S safety timer	Nozzle and bed targets set to zero after 30 minutes of inactivity; `M86` changes the time	Prusa-Firmware
Hot pull, PLA	200 to 220 °C	UltiMaker 2+
Hot pull, ABS or cleaning filament	240 to 260 °C	UltiMaker 2+
UltiMaker cleaning filament (polycarbonate)	260 °C on printers without a guided procedure	UltiMaker
Cold pull, PLA	80 to 100 °C	UltiMaker 2+
Cold pull, ABS or cleaning filament	140 to 160 °C	UltiMaker 2+
Cold pull, general	Around 90 to 140 °C for many materials	Polymaker
Outside of the nozzle and heater block	3 to 5 minutes at 250 °C, then a brass brush	Prusa CORE One
Routine cold pull	At least once a month	Bambu Lab
Printing too hot	Lower the nozzle in 5 to 10 °C steps	Polymaker

The timeouts come from Marlin's `Configuration_adv.h`, Klipper's configuration reference and the Prusa MK3S firmware source. The cleaning temperatures come from UltiMaker's nozzle cleaning and cleaning filament articles, Polymaker's nozzle clog guide, Prusa's CORE One maintenance article and Bambu Lab's clog prevention guide. PLA is polylactic acid and ABS is acrylonitrile butadiene styrene.

1.2 Why

Heat plus time breaks the plastic down. Polymaker says filament held in a hot nozzle oxidizes, "especially at higher temperatures", and printing above the filament's range speeds it up. Marlin's idle timeout exists for this reason: to "prevent filament in the nozzle from charring and causing a critical jam."

The residue collects where melt sits still. On a PTFE-lined (polytetrafluoroethylene) hotend, Polymaker warns that any gap between the tube and the nozzle makes a small chamber where filament "can expand, carbonize, and eventually clog." Bambu Lab adds that repeated short prints, with constant heating and cooling, speed up residue buildup. UltiMaker names PVA (polyvinyl alcohol) and composite materials as the most prone to degrading in the nozzle.

Buildup shows up in two places. Inside, UltiMaker says carbonized material causes extrusion problems, and "these burnt parts can show in your printed model." Outside, Prusa says plastic coating the nozzle affects its thermal properties, and residue on the nozzle or heater block can drop onto the print.

1.3 How do you remove carbon buildup from a nozzle?

- **Inside: hot pulls, then a cold pull.** UltiMaker pushes filament in at printing temperature and pulls it straight out; this "removes the majority of carbonized material." Cut the tip and repeat until it comes out fairly clean, then do a cold pull at the lower temperature. The cold pull steps and temperatures by material have their own pages.
- **Use a cleaning filament for heavy buildup.** UltiMaker sells polycarbonate sticks and calls polycarbonate the most effective material for clearing residue. E3D lists nylon cleaning filament as recommended for every V6 nozzle type, and as the only recommended method for Nozzle X. The two approaches are compared on the cleaning filament vs cold pull page.
- **Outside: heat, then a brass brush.** Prusa heats for 3 to 5 minutes at 250 °C, then brushes old plastic off the nozzle

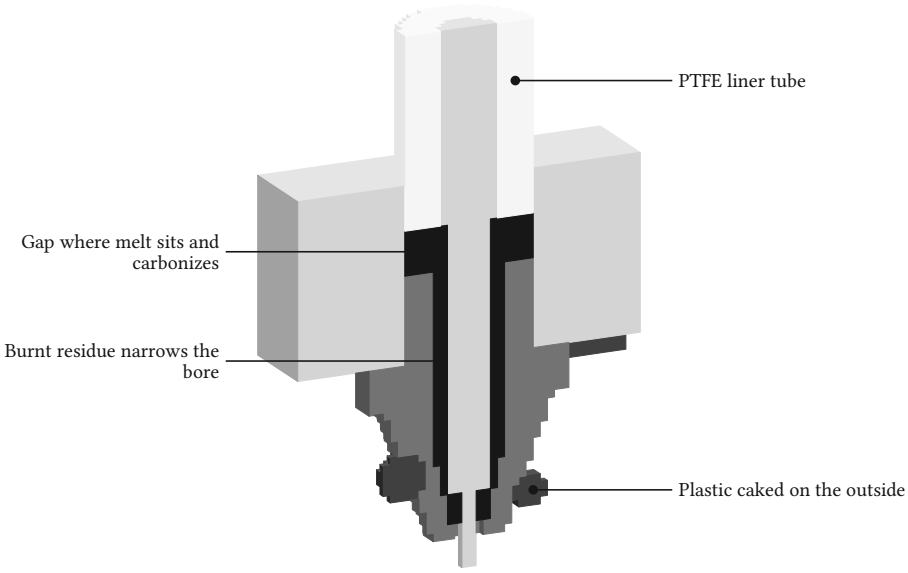


Figure 1. Residue collects where melt sits still, such as a gap between the tube and the nozzle, and burnt plastic outside the nozzle can drop onto the print.

and heater block. Keep the brush clear of the heater and thermistor wires. On the XL, Prusa turns the printer off before brushing.

- **Skip the blow torch and steel brushes.** E3D's V6 page lists a blow torch as non-recommended for every nozzle type. Steel wire brushes are on the same list for brass.
- **Needles are disputed.** E3D lists a needle as non-recommended, and UltiMaker never recommends one in the nozzle tip. Prusa uses its acupuncture needle on standard nozzles but not on its high-flow nozzles.
- **Replace it if pulls don't work.** When cold pulls don't restore flow, Polymaker says a nozzle change or a full hotend teardown may be needed.

1.4 How do you prevent carbon buildup?

- **Don't leave a loaded nozzle hot and idle.** Polymaker's advice is to lower the temperature or switch the heater off when you're not printing.
- **Check your firmware's idle timeout.** Klipper turns heaters off after 600 seconds by default, and Prusa's MK3S firmware after 30 minutes. Marlin's 5 minute timeout is off in the stock file. If you build your own firmware, enable `HOTEND_IDLE_TIMEOUT`.
- **Print within the filament's range.** If you see dark, burnt material or smoky fumes, Polymaker says to drop the nozzle 5 to 10 °C at a time.
- **Seat the PTFE tube flush** against the nozzle or heatbreak on a lined hotend.
- **Combine short jobs and keep the sock on.** Bambu Lab says frequent heating and cooling cycles speed up residue buildup. Its silicone nozzle sock reduces filament buildup.
- **Cold pull once a month,** Bambu Lab's interval, and when switching between filament types. Repeat clogs with other causes are covered in why a nozzle keeps clogging.

1.5 How to check it on your own print

- **Look for dark specks in the part.** UltiMaker says burnt material can show up in the printed model.
- **Look at the nozzle.** Polymaker's sign is dark, burnt material on the nozzle or the filament. Plastic caked on the heater block needs the 250 °C brush clean.
- **Read the pulled tip.** After a cold pull, a clean tip is a cone shaped like the inside of the nozzle. UltiMaker's rule: dirt or carbonized filament on the tip means cut it off and pull again.
- **Watch the flow.** Residue narrows the path, so underextrusion that gets worse over time points to buildup inside.
- **Test the timeout.** Heat the nozzle, leave the printer untouched and time how long the heater stays on. If it never shuts off, set or enable a timeout.

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