Printing Better-Fitting Dust Gaskets with a Single Foamed Extrusion

How FiberFlex Aero simplified the toolpath and improved installation in static enclosure grooves

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Executive summary

Patient Lifting Solutions (PLS) uses an internal gasket in its wall chargers to exclude dust from a static enclosure interface. The original solution was gasket cord supplied on a reel. Cutting each length and placing it in the groove took too much assembly time, while purchasing custom-moulded gaskets was uneconomic at the required volumes. Moving to 3D-printed TPU produced inexpensive, geometry-specific gaskets that were quick to install.

The conventional TPU print process, however, was unstable. Conventional slicing generated several adjacent extrusion features, together with starts, stops and travel moves. Blobbing, stringing and post-pause gaps created local irregularities and discontinuities. Fourteen gaskets required approximately one hour of printer time, and defects could compromise an otherwise useful batch.

The improved method combines Fiberlogy FiberFlex Aero with a deliberately generated FullControl toolpath. The material's heat-activated foaming agent enables a nominal 0.40 mm track to expand into the wide, compliant bead needed by the gasket.[1] PLS bypassed conventional object slicing and generated one tangent-continuous centreline extrusion. Five same-direction turns build the required height without interrupting the bead. The current fourteen-gasket job takes approximately 15 minutes, increasing batch throughput by roughly a factor of four.

Core result. FiberFlex Aero made a wide continuous extrusion possible, while the custom toolpath removed the intra-gasket travel, retraction and pause events that caused blobs and post-pause gaps. The foam texture increased fault tolerance and compressed readily into the groove. Fourteen-gasket print time fell from approximately 60 minutes to approximately 15 minutes.

01

Custom toolpath
FullControl generates one continuous centreline track instead of a sliced cross-section.

02

Cleaner continuity
No pause, travel or retraction occurs inside a gasket instance.

03

Easier installation
The foamed bead compresses and remains located in the groove.

1 Application, constraints and process history

The gasket is an internal part of a PLS wall charger. It is installed in a groove around the perimeter of a rigid enclosure and closes the interface sufficiently to discourage dust ingress during normal static use. It is not exposed as a user-facing component.

The manufacturing route evolved in three steps. Reeled gasket cord was technically adequate but labour-intensive to cut and install. Custom-made closed-loop gaskets would have reduced assembly work but were too expensive. Conventional TPU printing then delivered a low-cost, geometry-specific loop that was quick to install, but its slicer-generated toolpath made printing unreliable. The foaming-TPU process retained the cost and installation advantages of the printed gasket while addressing the process instability.

Table 1: *Defined application boundary*

Intended	Static dust exclusion in a recessed enclosure groove; straightforward placement and retention during assembly.
Not intended	Pressure sealing, fluid sealing, sliding or reciprocating motion, repeated servicing, or a safety-critical sealing function.
Observed criterion	A continuous gasket that fits the path, compresses easily into the groove and remains seated while the enclosure is closed.
Not yet established	Leak rate, ingress-protection rating, compression set over service life, chemical resistance in the assembly, or validated disassembly cycles.

This boundary keeps the development proportionate. The objective was not to qualify a general-purpose seal; it was to manufacture a geometry-specific dust barrier more reliably and make assembly less sensitive to local print defects.

[1] Fiberlogy, "FiberFlex Aero," product information, accessed August 2026: https://fiberlogy.com/en_US/c/FiberFlex-Aero/206.

2 Why conventional TPU slicing struggled

A gasket can look geometrically simple in CAD while producing a complicated extrusion sequence. When the cross-section is represented as a small solid body, a conventional slicer may generate multiple perimeters, short connecting moves and local start/stop events. Retractions and travel movements add further opportunities for stringing and material accumulation.

For a rigid component, minor surface artefacts may be cosmetic. For a flexible gasket placed into a narrow groove, the same artefacts are functional: a blob can prevent local seating, a string can fold underneath the bead, and a discontinuity can make the loop behave unevenly during installation.

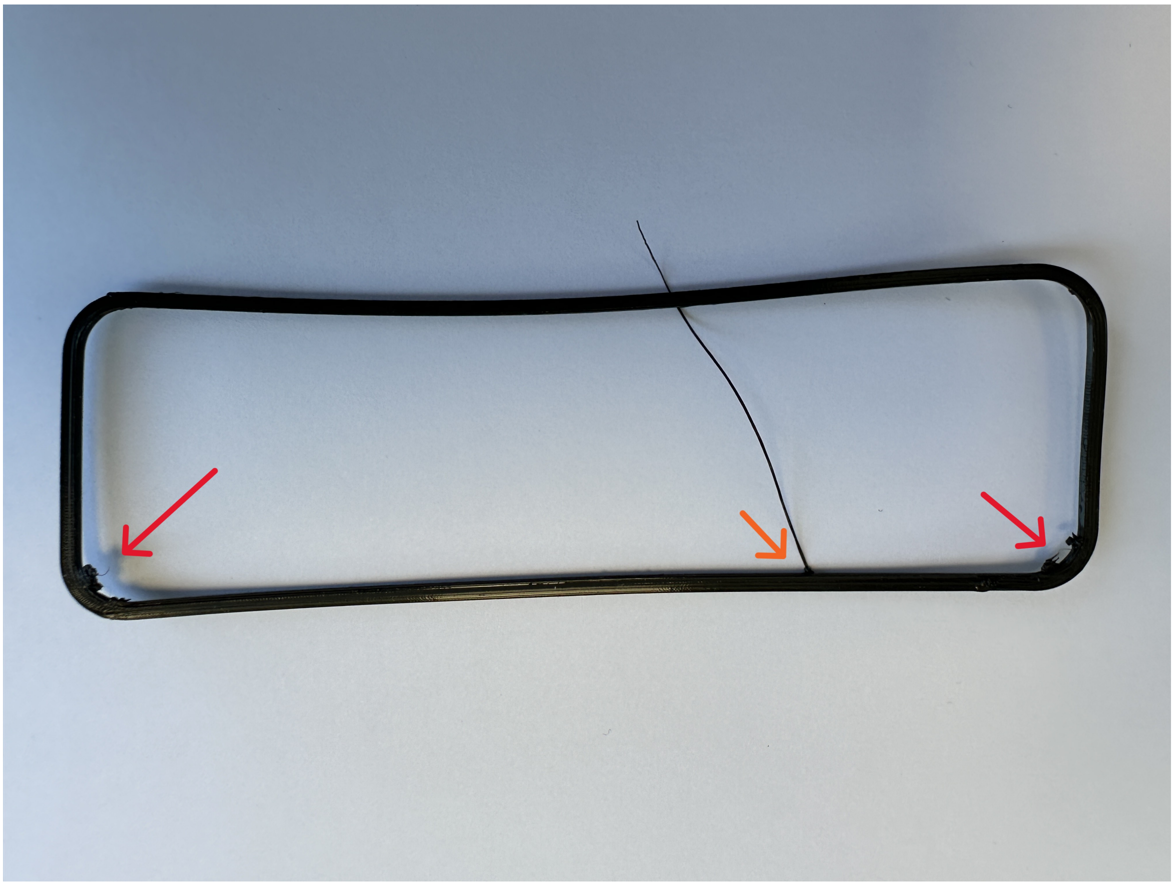

Figure 1: *Typical defects in a conventionally sliced TPU gasket. The arrows identify accumulated material at corners and a long string left by non-depositing motion.*

Simply replacing the sliced paths with one continuous centreline was not practical with the previous non-foaming TPU. In the tested setup, a 0.40 mm nozzle could not create a sufficiently thick single extrusion to fill the 1.47 mm gasket band. Adjacent paths were therefore needed, reintroducing the seams and transitions that destabilized the print. The foaming material changed that geometric constraint by expanding after it left the nozzle.

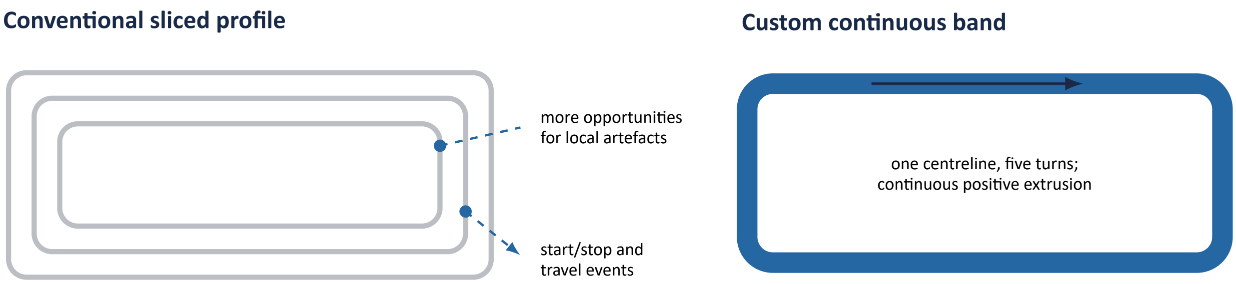

Figure 2: *Conceptual toolpath comparison. The custom method bypasses conventional object slicing and generates one uninterrupted centreline path.*

3 The continuous-band process principle

The source STL is a full three-dimensional gasket body with a 1.47 mm-wide band. A Python generator extracts one centreline from that band and approximates it with XY segments no longer than 1.0 mm. This centreline becomes the base XY shape for a five-turn helical toolpath generated with FullControl, an open-source system for explicitly designing print paths and producing G-code without conventional slicing.[2]

This is different from modelling the gasket as a thin one-wall part or asking a slicer to exaggerate its line width. Vase mode was also unsuitable: because the source is a complete 3D band with thickness, a conventional vase-mode contour would not recover the required wall path through the centre of that band. Instead, the extracted centreline is repeated in the same direction while Z rises by one 0.28 mm layer between turns. Each transition occurs over 5 mm of travel along the XY path; five turns produce the specified 1.40 mm gasket height while remaining one uninterrupted extrusion.

FullControl generates the gasket's object motion only. The "proven Bambu Lab package" is a previously sliced `.gcode.3mf` file exported from Bambu Studio. It supplies the machine-specific G-code flavour, startup sequence and shutdown sequence used by the printer. The generator preserves those executable wrapper blocks and replaces only the original sliced object-motion block, then recalculates the package metadata, checksums and previews.

FiberFlex Aero expands as it leaves the nozzle, allowing a nominal 0.40 mm stadium-model track to form a much broader cellular bead. The manufacturer describes the foaming level as controllable through nozzle temperature, material flow and print speed.[3] This expansion is what makes the continuous centreline approach possible; the earlier non-foaming TPU could not produce the required bead width as one track in this setup.

The 0.28 mm layer height was selected to leave sufficient clearance beneath the nozzle and limit back pressure. With a foamable melt, too little clearance can impede the expanding flow, stall extrusion and create additional discontinuities. Layer height, temperature, speed and extrusion multiplier therefore have to be treated as coupled process controls.

Figure 3: *Several complete gasket loops printed on one build plate. The repeated geometry makes toolpath consistency and defect prevention especially important.*

The production logic can be summarized in four steps:

1. **Recover the centreline.** Derive one continuous path from the STL's 1.47 mm gasket band while preserving the corner geometry.

[2] A. Gleadall, "FullControl GCode Designer: Open-source software for unconstrained design in additive manufacturing," *Additive Manufacturing*, vol. 46, 102109, 2021, `https://doi.org/10.1016/j.addma.2021.102109`. Python implementation and documentation: `https://github.com/FullControlXYZ/fullcontrol`.

[3] Fiberlogy, "FiberFlex Aero Filament - 1.75 mm - 0.85 kg," product information, accessed August 2026: `https://fiberlogy.com/en_US/p/FiberFlex-Aero-Filament-1.75-mm-0.85-kg/830`.

2. **Generate uninterrupted motion.** Create a five-turn helical outline with positive extrusion on every move and a one-layer Z rise over 5 mm of XY travel between turns.
3. **Tune the foam response.** Balance temperature, speed and layer-specific extrusion multipliers until the expanded bead approaches the intended band width.
4. **Package and verify.** Insert the object motion between the proven Bambu Studio start and end blocks, recalculate metadata and previews, then judge the gasket in the groove-and-cover system.

4 Why installation improved

The original fit problem had two components. First, local TPU artefacts changed the effective cross-section. Second, a comparatively dense elastic bead resisted being placed and retained around the full perimeter at once. Correcting one area could cause another area to lift from the groove.

The foamed extrusion changed this installation behaviour. Its cellular section compressed with less force and accommodated small local variation. Once pressed into the recessed path, it was less inclined to spring out before the enclosure could be closed. Installation became a controlled placement task instead of a repeated cycle of stretching, repositioning and correcting defects.

Figure 4: *Installed FiberFlex Aero gasket following the enclosure groove. The foam texture allows the bead to compress and remain seated during assembly.*

> **Engineering interpretation.** The foam does not compensate for an incorrect groove or uncontrolled extrusion. It increases the available installation tolerance within a deliberately matched groove, bead and compression range.

5 Process controls and development method

The production source of truth is a machine-readable gasket configuration in the PLS foaming-TPU repository. This separates executable settings from development notes and calibration evidence. Table 2 records the current Bambu Lab A1 configuration for the gasket.

Table 2: *Current Bambu Lab A1 production configuration*

Control	Production value	Purpose or interpretation
Printer / nozzle	Bambu Lab A1 / 0.40 mm	Proven direct-drive machine wrapper; standard nozzle.
Nozzle / bed temperature	240 / 45 °C	Production setpoints for the current Bambu job.
Layer height / turns	0.28 mm / 5	Produces a specified finished height of 1.40 mm.
Nominal track model	0.40 mm stadium	Calculation model for the unfoamed deposited cross-section.
Motion speed	20 mm/s	Coupled to the foaming response; not merely a cycle-time choice.
Extrusion multiplier	2.5 first turn; 2.8 upper turns	Independent values used to establish the first turn and maintain the upper bead.
Part cooling	0%	No part-cooling fan in the current production configuration.
Configured flow ceiling	10 mm^3/s	Validation limit for this job, not a universal FiberFlex Aero limit.
Batch layout	14 instances, 2 × 7	Each five-turn gasket is completed before moving to the next.

The generated package reports a total estimated print time of 15 minutes 7 seconds for the fourteen-gasket job. The earlier conventional TPU process produced the same quantity in approximately one hour. The nominal centreline length of one gasket is 257.97 mm and its source footprint is approximately 103.49 by 33.19 mm.

5.1 Why uninterrupted motion is mandatory

During development, FiberFlex Aero continued expanding whenever the nozzle stopped. A pause forced material from the stationary nozzle and formed a blob; the nozzle then resumed in a depleted state, leaving an extrusion gap that could continue for several centimetres. This explains why ordinary seam tuning was insufficient.

Within each gasket, the generator therefore prohibits waits, dwell commands, travel moves, retractions, zero-length extrusion and direction reversals. Heating and synchronization finish before the final positioning move. That move is followed immediately by positive extrusion. Between completed gasket instances, one rapid non-extruding move repositions the nozzle; no such move occurs inside an instance.

5.2 Flatbed-scanner width mapping

Early straight-line tests measured the foamed bead at five temperatures. These measurements were made with the earlier 0.60 mm nozzle and explain the initial selection of 240 °C; they are not a physical calibration of the current 0.40 mm production nozzle.

Table 3: *Historical temperature-line measurements at 20 mm/s and 0.28 mm layer height*

Temperature	Line 1 width	Line 2 width	Mean / spread
200 °C	0.00 mm	0.60 mm	0.30 / 0.60 mm
210 °C	1.00 mm	0.85 mm	0.93 / 0.15 mm
220 °C	1.00 mm	1.20 mm	1.10 / 0.20 mm
230 °C	1.30 mm	1.40 mm	1.35 / 0.10 mm
240 °C	1.40 mm	1.40 mm	1.40 / 0.00 mm

The stable 240 °C result supported using one centreline for the 1.47 mm band. PLS then developed a higher-density width map for the current 0.40 mm nozzle. One build plate carries 77 straight lines: seven nozzle temperatures (200, 210, 220, 230, 235, 240 and 250 °C) crossed with eleven target volumetric flows from 1.50 to 9.00 mm^3/s in 0.75 mm^3/s

increments. Layer height (0.28 mm), motion speed (20 mm/s), bed temperature (45 °C) and part cooling (0%) remain fixed.

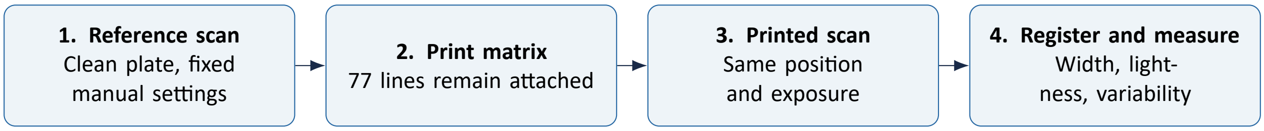

Figure 5: *Flatbed-scanner measurement workflow. The empty and printed plate are scanned as a registered pair.*

Both scans are made at 600 DPI in 24-bit RGB with automatic exposure, contrast, sharpening, colour restoration, dust removal, descreening, rotation and cropping disabled. The plate is kept in the same physical position, and the printed lines remain attached for the second scan. Lossless TIFF files with identical dimensions and settings are required.

The analysis registers the carbon weave and fixed scratches in the plate, corrects modest exposure drift, and samples many windows along each line. It reports line width, relative lightness and within-line width variability. Relative lightness is used only as an empirical indicator of foaming, not as a calibrated foam fraction. Missing or merged lines are marked invalid rather than estimated, and the measurement export does not automatically alter production settings.

The accepted scan subset excluded the 200 and 210 °C groups because extrusion was intermittent or missing. Of the remaining 55 expected lines, 52 were measured and three were rejected as merged. Because temperature, flow, speed, nozzle diameter and cooling are coupled controls, the resulting matrix applies only to the tested machine, nozzle, material and setup.

5.3 Acceptance checks

For this dust-exclusion application, a pragmatic inspection can remain simple:

- The extrusion is continuous around the entire loop.
- No blob, string or thin section prevents the bead from entering the groove.
- The gasket can be placed without excessive stretching.
- The gasket remains seated while the mating enclosure part is positioned.
- Closing the enclosure produces visible, reasonably uniform compression without cutting or displacing the bead.

These checks verify manufacturability and installation. They do not establish an IP rating or pressure-sealing capability.

6 Observed comparison

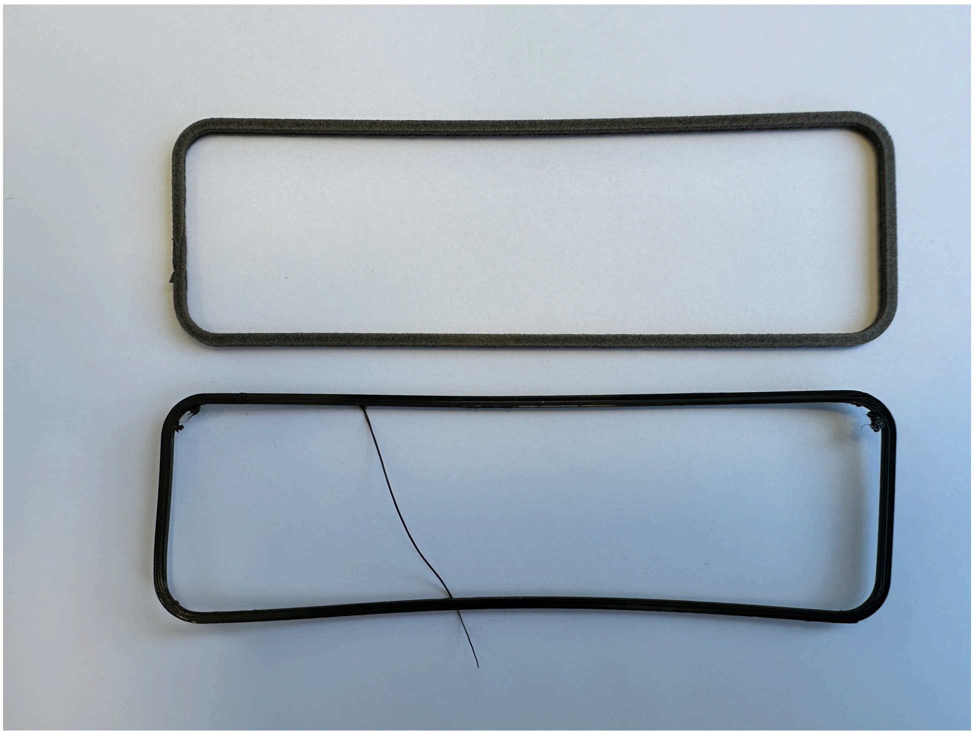

Figure 6: *Direct comparison of the FiberFlex Aero gasket (top) and the conventional TPU gasket (bottom). The foamed bead is wider, more compliant and more tolerant of small local variation.*

Table 4: *Qualitative comparison observed during development*

Characteristic	Conventional TPU approach	FiberFlex Aero continuous-bead approach
Toolpath	Slicer-generated walls, seams and transitions	FullControl-generated centreline; five continuous same-direction turns
Defect opportunities	Blobs and strings associated with stops, travel and restart events	No pause, travel or retraction inside one gasket instance
Cross-section	Dense printed geometry; fit sensitive to local artefacts	Nominal 0.40 mm track expanded into a broad, foam-textured bead
Groove placement	Difficult to fit and keep located around the perimeter	Easier to press into the groove and retain during assembly
Batch print time	Approximately 60 minutes for 14 gaskets	Approximately 15 minutes for 14 gaskets
Functional scope	Intended as a static dust barrier	Same limited static dust-exclusion duty
Evidence level	Practical production and assembly observations	Practical production and assembly observations; not a sealing qualification

The principal improvement was therefore process robustness at the point where printing meets assembly. The material's expansion created the required bead width from one centreline, the foam texture made local defects less consequential, and the custom toolpath removed the main sources of stops and restarts. The gasket remained inexpensive and quick to install while batch printer time fell by approximately 75%.

7 Conclusion

PLS improved an internal wall-charger gasket by changing the design question. Instead of asking how to reproduce a small solid TPU profile with conventional slicing, the team asked how to create the required functional bead with controlled, uninterrupted motion.

This approach became practical because Fiberlogy introduced FiberFlex Aero. Its heat-activated expansion allowed a nominal 0.40 mm deposited track to approach the 1.47 mm gasket band, something the previous non-foaming TPU could not achieve as one continuous track in the tested setup. FullControl then made the five-turn helical path explicit. The foam texture compressed readily into the enclosure groove and remained located during assembly, while removing intra-gasket pauses, travel and retractions addressed the root mechanism behind blobbing and post-pause discontinuities.

For this static dust-exclusion duty, the combination provided the useful outcome: a cleaner and faster continuous print with more forgiving installation. PLS thanks Fiberlogy for drawing our attention to FiberFlex Aero and for making this unusual process route available through the development of the material.

Acknowledgements and AI usage statement

Engineering contribution. Fabian Trauzettel originated the concepts, test strategy and process ideas; performed the physical experiments; selected and interpreted the settings; inspected the prints; and provided the human verification and final engineering decisions.

AI-assisted implementation. ChatGPT Codex was used as an implementation partner during this side exploration. Under Fabian's direction, Codex generated and revised the Python code, adapted the object-motion generation around example `.gcode.3mf` files exported from Bambu Studio, implemented packaging and validation logic, and assisted with analysis tooling and preparation of this whitepaper. Fabian worked concurrently on other projects, supplied iterative input, ran the physical tests and accepted or rejected the generated results in a human-in-the-loop workflow. Codex did not independently perform physical validation or authorize production changes; responsibility for the engineering conclusions remains with the author.