

## How to Regain Design Freedom with Extruded Profile Guides

By Brian Burke, Product Manager

### INTRODUCTION

Linear guides are one of the most important components required for the development of automated or computer controlled equipment. They enable smooth and accurate motion for the primary machine functions and can be used on covers, guards, and equipment drawers. 3D printers, CNC routers, and tabletop factories wouldn't function without them.

During the development phase, most design engineers will survey existing manufacturers for standard linear guide products to incorporate into their projects. Invariably, the designer will need to make compromises in their selection process and accept limited design freedom on purchased products. Perhaps the available guides are too large, are the incorrect shape, require additional modifications, and may have unstable supply quantities. Extruded profile based linear guides provide design freedom and can incorporate additional features to lower the overall complexity of a machine.

### NEW TECHNOLOGY

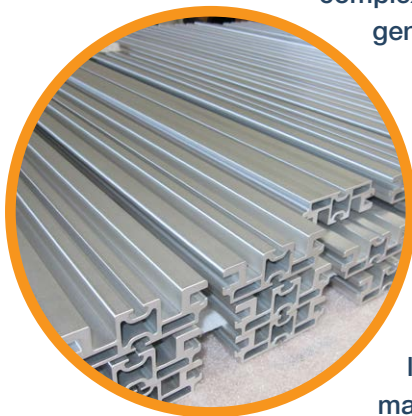
The QuickTrak modular linear guide product line from Bishop-Wisecarver is based upon extruded aluminum profiles in standardized shapes. They feature hardened carbon steel, 90-degree vee guide tracks that are permanently installed into extruded support bases. These track designs feature a patented track retention technology where small extruded fingers in the material experience elastic deformation to retain the guide track all along the linear length. This development enables permanent track retention without the need for adhesives or fasteners. This finger retention method can be applied to almost any aluminum extrusion design.



Track clamp wedges with flexible fingers

### EXTRUSION PROCESS

Aluminum extrusions can be produced in an infinite variety of shapes and sizes to suit dedicated purposes. Extrusions are made when preheated aluminum is forced at very high pressures through the pre-cut opening of a tooling die. The shape of the die opening can be simple such as a solid circle or rectangle, or it can be complex with multiple holes and thin features. As the material exits the die it is gently pulled and stretched to counteract twisting and warping as it cools.



Finished aluminum extrusion with clear anodize

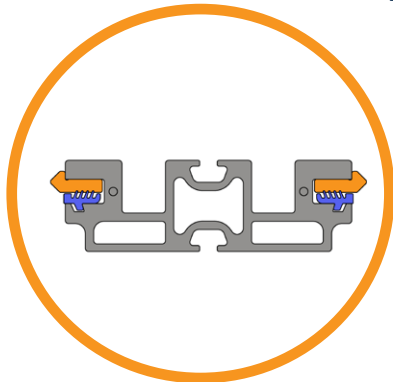
There are many grades of aluminum but the 6000 series is typically used in the extrusion process. Some common grades for these purposes include 6005, 6061 and 6063. Shortly after the extrusion process they can be heat-treated to improve the material properties. An example is 6061-T6 which is commonly referred to as aircraft grade aluminum. These materials are rigid and durable, with excellent corrosion resistance. Finishing operations such as anodizing can be applied to the surfaces in any color with varying layer thickness. Extruded 6000 series aluminum is an ideal substrate for machine bases and linear guides.

# MACHINE BUILDING BLOCKS

The primary motion axes of CNC routers, 3D printers and other machines can be fabricated from aluminum profile extrusions, and they can be designed to accept hardened steel linear guide way vee tracks to make integrated linear guides. This concept enables design freedom and the ability to incorporate additional machine features into the profile extrusion. Machines produced with this methodology can be greatly simplified. This white paper highlights some of the major concepts and their benefits.

## Lower Overall Cost

The cost to assemble each machine can be greatly reduced because an extruded profile guide eliminates the need to install, align and adjust separate traditional linear guides. The time and labor required to complete the linear guide installation is reduced because extruded profile guides are supplied as complete sub-assemblies with the steel linear tracks already installed.

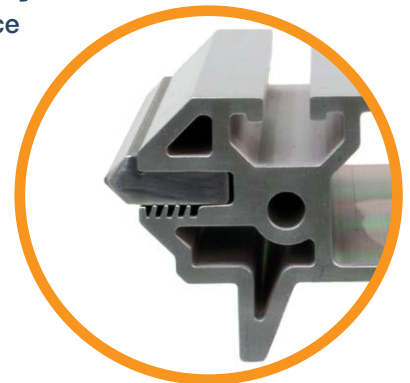


Installed linear guide tracks are inherently parallel

## Reduced Bill of Material Complexity

Sourcing an extruded profile guide will reduce the number of items on a machine bill of materials. The linear guide components are integrated into the extruded beam and are a single component part. This can reduce the amount of engineering documentation

necessary and fewer parts will need to be inventoried and processed during the machine build cycle. Contrast this to the process of installing traditional linear guides using fastener hardware involving torque specifications and adhesive thread locking fluids. This reduction in complexity can result in a substantial cost savings.



Permanent assembly without adhesives or fasteners

## Flexibility in Length

Aluminum extrusions are made in a long and continuous process. Later, they are cut down to usable lengths. A family of machines can be designed around the same extrusion profile and each machine design can use various lengths for the motion axes. An example would be a CNC router machine that processes 4'x8' sheets of plywood. The same extruded profile guide could be used for both the X-axis and the Y-axis, typically in an X, X-Prime, Y gantry configuration. One machine of this design would use 20 feet or more of the same extrusion. A single production run of material can yield enough material to produce an entire family of various machine designs.



LoPro gantry system X-X' Y Z configuration

## Structural Integrity

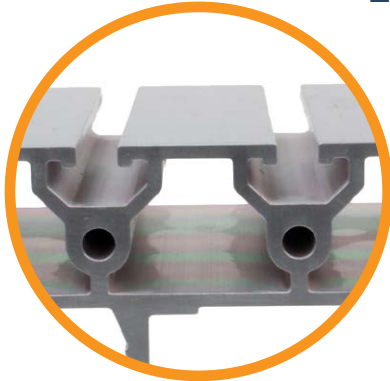
Extruded profile guides can be manufactured with significant structural rigidity and enable the linear guides to be used in an unsupported fashion over large machine spans. This is ideal for large travel machines that process large work pieces. Several common machine applications include gantry routers, CNC cutting tables, plasma tables, water jet machines, and laser cutting machines. Although a larger beam design with

more cross-sectional area is required, it is not uncommon to span unsupported over 10 feet or more. Beam deflection calculations can be provided as needed.

## DESIGN IDEAS AND FEATURES

There are many possible features that can be designed into a single extruded profile. Each feature can serve a variety of purposes. Most design features are functional and are intended to provide a means of attaching additional components. However, some features can be used simply for their form and to provide aesthetically pleasing shapes. One example is to include small ripples, or ridges, on larger extruded surfaces to break up space and make it more pleasing to the eye. Some of the major useful design features that can be extruded into shape are outlined below.

### Extruded Features: T-Slots

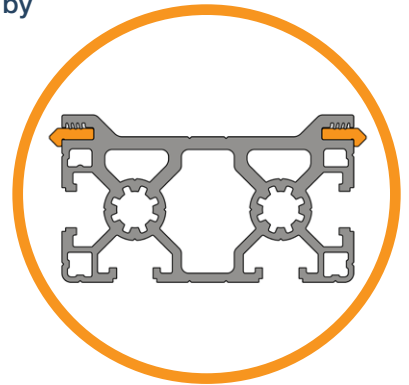


Extruded T-slot features

T-slots are useful. Their utility is self-evident. They have been used on machinery for more than a century. Vertical knee mills and CNC machines have t-slots on the working table surfaces for attaching a variety of fixtures and work pieces. T-nuts and bolts are used in the t-slots to attach material. Extruded t-slot features can be easily incorporated into a design and they provide a means of attachment anywhere along the length of the extrusion. T-slots can be used for attaching the extruded profile guide to a larger substrate such as a steel beam or a granite base. A t-slot feature can also be used to attach to other t-slots in the case where a machine is fabricated from t-slot profiles. Rubber feet, cable carriers, linear gear racks, covers, sheet metal brackets and other mechanical components can all be attached to t-slot features.

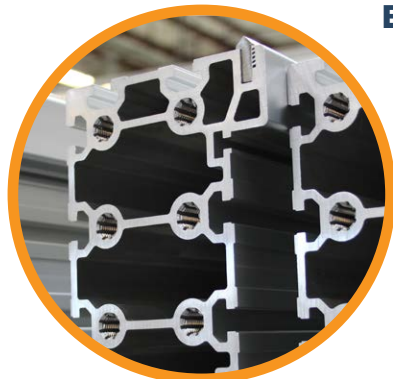
### Extruded Features: Cavities

Aluminum extrusions are typically produced by an extrusion company and sold by the pound. The design of the tooling die is measured in total square inches of opening, enabling a simple calculation to determine the pounds per foot of the resulting product. Companies that provide the extrusion will have a minimum amount, measured in pounds, or in linear length, to produce a batch of extrusion. A minimum batch could have a wide variation in final linear length based upon the cross-sectional area of the tooling die. A profile with holes, voids, and thin sections will have a lower cross-sectional area and will be of lower weight per foot. These holes and internal shapes on the extrusion can serve useful purposes. In the case of linear motion applications, internal cavities can be used as a void for belt or chain returns, can hold internal wiring, or can be designed simply to reduce the weight.



Cavity design for even wall thickness

### Extruded Features: Holes

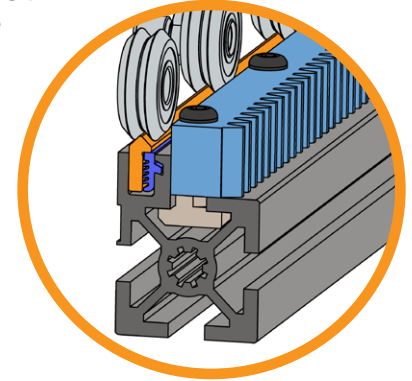


Threaded holes for attachment

Round cavities, or other similar shapes can be included in the extrusion die design. These features are particularly useful when they are sized for secondary thread tapping. The ability to thread tap an extrusion provides many possible benefits. The end threads can be used as attachment points for brackets and enable multi-axis gantry configurations. Threaded holes can also be used for attaching end caps, end seals, or other finishing materials. In some applications, an extruded hole can be used to convey pressurized fluids or gas such as high pressure air because the necessary fittings can be easily attached at these locations.

### Extruded Features: Power Transmission

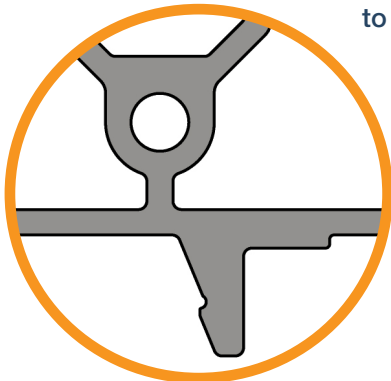
Extruded profile guides can be designed to incorporate specific areas for attaching power transmission components such as linear gear racks. Typically, a flat section of the extrusion is used with a small reference edge to simplify alignment. A secondary machining operation to add threaded holes down the linear length may be required for attaching the gear rack. Other possible alternatives to attach the gear rack include using high strength adhesives, or mounting over t-slot features. Integrating the location for gear rack attachment into the extrusion ensures that the vee guide surfaces are parallel to the power transmission components making for a compact and simplified motion axis sub-assembly.



Rack located on reference edge and attached via t-nuts

### Extruded Features: Feedback

Another useful design feature for extruded profile guides is specific geometry for attaching linear tape encoders to provide position feedback



Location for attaching linear encoder

to the machine control system. Similar to the attachment of gear racks for power transmission, a flat area with a reference edge can be incorporated for locating and adhering the linear tape encoder. The addition of an encoder will provide position feedback to the machine control system.

### Extruded Features: Cable Carriers & Wire Ducts

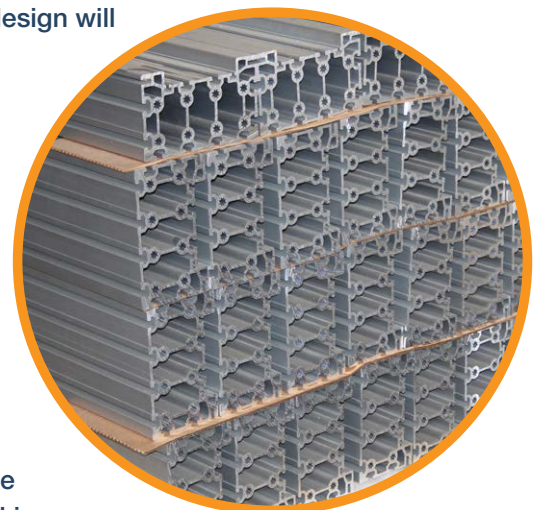
Internal or external features can be incorporated for attaching cable carriers or wire ducting to simplify the electrical requirements of a machine. These features can be simple such as machined threaded holes, or can be complex such as extruded ripples for specific wire diameters. It is also possible to have a secondary extrusion attach to the primary extrusion to act as a wire duct lid.

## INTELLECTUAL PROPERTY

When you design and source an extruded profile guide that is specific to your machine application, you maintain control of the intellectual property. Your competitors will not be able to easily copy your design or simply purchase the same parts that you do from the same suppliers. The extrusion tooling die used to produce your profile is yours. You take control of the supply chain and will not be subjected to back-order or inventory shortages from the manufacturer. Additionally, your design will never be subject to a manufacturer discontinuing the product line.

## PRODUCTION VOLUMES

Initially it may sound prohibitive to source a custom, application specific extruded profile guide but the required minimum order quantities are much lower than most engineers expect. The minimum extrusion run is set at 100 meters, or about 330 feet of material. This would be too much material for a one time project, but for many machine build scenarios this minimum quantity is quite accommodating. In the previous CNC router machine example that processes 4'x8' plywood sheets requires around 20 linear feet. With a minimum amount of extrusion at 330 feet, and using 20 feet per machine build, only 16 machines can be made. Typical machine builders are working toward machine builds in lifetime quantities of several hundred. This is plenty of opportunity to consume the minimum amount of extrusion.



Production quantity of extruded profile guides



## CONCLUSION

Linear guides are one of the critical components required for building automated and computer controlled machines. Most designers utilize standard linear guide products from existing manufactures, and as a result, must accept limited design freedom in their selection process. A new alternative, is to design the right linear guide, with integrated features for simplified machine designs. Hardened steel 90-degree vee guide track can be incorporated using the finger retention method for providing smooth, debris-tolerant motion. Extruded profile guides are application specific which helps to protect intellectual property and prohibits competitive pressures while securing the supply chain. They are supplied in low quantities and enable a lower total cost per machine.



Assembled double edge  
profile guide



## AUTHOR BIO

Brian Burke is a Product Manager at Bishop-Wisecarver with more than 10 years of experience in the automation industry and extensive lean manufacturing knowledge. With a background in computer aided design and new product development, he brings automation to market via literature, catalogs, and trade show expositions.

## ABOUT

Bishop-Wisecarver Group is a woman-owned family of WBENC certified companies in its second generation, and has remained one of the most respected names in custom automation solutions and guided motion technology since 1950. The San Francisco Bay Area company manufactures, stocks, and distributes guided motion components and systems for linear, rotary and curved track applications. Bishop-Wisecarver products are used worldwide in industries such as packaging, medical device manufacturing, wood processing, food processing and semiconductor fabrication.