



## **INTRODUCTION TO DESIGNING EXTRUDED PLASTIC PROFILES**

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COOPER STANDARD  
INDUSTRIAL & SPECIALTY GROUP

# INSIDE

SECTION	PAGE
DESIGN BASICS .....	3
CHOOSING MATERIALS .....	4
UNIFORM WALL THICKNESS .....	7
CORNERS .....	8
SINK MARKS & HOLLOWES .....	9
TOLERANCES .....	10
PLASTIC VS. RUBBER .....	11
PLASTIC VS. ALUMINUM .....	15
CASE STUDIES .....	16
1. Extruded Plastic Base Improves Silicone Seal Installation	
2. Diverse Performance Capabilities	



## **STARTING YOUR PROJECT**

Engineers must consider several factors to ensure plastic components both perform properly and are produced efficiently. These include the application environment, assembly processes, aesthetic requirements, critical tolerances and more. Fully understanding these issues also can lead to opportunities for cost savings or product enhancements.

This guide provides an overview of concepts that can be applied to effectively designing extruded plastic profiles. Rely on Cooper Standard ISG's dedicated engineers to help you optimize your design and determine the best material option for your requirements.



## DESIGN BASICS

Plastic parts can range from simple profiles to complex dual- and tri-durometer extrusions in which different materials are extruded together to enhance performance properties.

For example, rigid and flexible materials may be combined to create a part that installs easily while offering dynamic sealing or protective features.

Processes such as cutting, drilling and notching can often be performed efficiently in-line with product extrusion. More complex designs and assemblies can be achieved offline in specifically-designed work stations.

Cooper Standard ISG's production and tooling capabilities, market experience and organizational sophistication are among the factors that will play a role in delivering high-performing, cost-effective solutions.

During an initial assessment, the profile design, materials, tooling and processing needs are all evaluated.

Additional attention is given to how the part will be installed or joined with mating components. By weighing each of these variables, Cooper Standard ISG engineers can recommend the best package of solutions for your specific application and production timeframe.



# CHOOSING MATERIALS

Choosing the right plastic resin ensures you will meet performance demands.

While rigidity is generally determined by the resin material, plastic blends can be developed to meet many needs. These include operating temperatures, UV resistance, coloration or opacity, flame resistance and more.

Plastic materials can be extremely rigid or can mimic the elastomeric properties of rubber depending on the resin used.

**Every material has benefits and limitations. Typically, it is best to identify a material that will provide a balance of the desired properties.**

## RIGID THERMOPLASTIC MATERIAL PROPERTIES

MATERIAL	MPR	LDPE	ABS	NYLON	PC	HDPE	PP	RPVC	HIPS
STRENGTH	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	High
TOUGHNESS	High	High	Medium	Medium	High	Low	Low	Medium	High
STIFFNESS	Low	Low	High	Medium	High	Low	Medium	High	High
HIGH TEMP LIMIT (°C)	135°	80°	80°-90°	120°-140°	110°-130°	80°-90°	90°-110°	100°-120°	60°
LOW TEMP TOUGHNESS	High	High	Medium	Low	High	Medium	Low	Medium	High
COST	Medium	Low	Medium	High	Medium	Low	Low	Low	Medium
CHEMICAL RESISTANCE	High	High	Low	High	Low	High	High	Medium	Low
WEAR RESISTANCE	High	High	Low	High	Low	Medium	Low	Low	Low
WEATHERABILITY	High	Medium	Low	Low	Medium	Medium	Low	High	Low
HARDNESS R	35-50	55	105	85	120	90	95	105	61

MATERIAL KEY: MPR (Melt Processable Rubber); LDPE (Low-Density-Polyethylene); ABS (Acrylonitrile-Butadiene-Styrene); PC (Polycarbonate); HDPE (High-Density-Polyethylene); PP (Polypropylene); RPVC (Rigid-Polyvinyl-Chloride)

## FLEXIBLE THERMOPLASTIC MATERIAL PROPERTIES

MATERIAL	TPV	TPO	TPU	FPVC
DENSITY	Medium	Low	High	High
TENSILE STRENGTH	Medium	Medium	High	Medium
ELONGATION	High	High	High	Medium
HIGH TEMP LIMIT (°C)	125°	80°	150°	100°
LOW TEMP LIMIT (°C)	-60°	-60°	-40°	-30°
COST	Medium	Medium	High	Low
WEAR RESISTANCE	Medium	Medium	High	Medium
WEATHERABILITY	Medium	Medium	Medium	Medium
HARDNESS A	50-90	70-90	70-90	60-90

MATERIAL KEY: TPV (Thermoplastic Vulcanizate); TPO (Thermoplastic Polyolefin); TPU (Thermoplastic Polyurethane); FPVC (Flexible-Polyvinyl-Chloride)

# PLASTIC MATERIALS

Plastic materials can be designed to meet many needs, including operating temperatures, UV resistance, coloration or opacity and flame resistance.

An important design consideration for plastics is whether the profile needs to be rigid or flexible. Rigid plastics work well for applications in which durability and impact resistance are important. Flexible plastics can be engineered to mimic the physical properties of rubber when those characteristics are desired.

**PVC** (Polyvinyl Chloride) ranges from rubbery soft to rigid. Flexible PVC is widely used for plastic profile extrusions because of its resistance to abrasion and ability to insulate. Flexible PVC is commonly used for impact resistant bumpers, weatherstripping, cushioning devices and flexible tubing. Tough and economical, rigid PVC is inherently flame retardant and resistant to most chemicals. Rigid PVC can be offered in clear, opaque, weather resistant, high-tensile-strength and impact-resistant formulations that are easily machined.

**HIPS** (High-Impact Polystyrene) is a rigid, economical, lightweight plastic which is used for rigid plastic profile extrusions and plastic tubing extrusions. High-impact polystyrene typically has a flat finish and is available in natural (translucent white), standard and custom colors.

**ABS** (Acrylonitrile Butadiene Styrene) is a versatile, rigid and high-impact plastic with good chemical resistance to most non-aromatic compounds. It is used primarily in plastic profile extrusion applications where material will be indoors. ABS has a satin finish and is available in standard or custom colors.

**ASA** (Acrylonitrile Styrene Acrylate) is produced by introducing acrylic elastomer during the reaction between styrene and acrylonitrile. ASA material has great toughness and rigidity, good chemical resistance and thermal stability, outstanding resistance to weather, aging, yellowing and high gloss.

**EPP** (Expanded Polypropylene) is an exceptionally eco-friendly, flexible and versatile plastic foam designed for lightweight, energy-management and cushioning applications. EPP can replace materials such as metals, wood and a variety of other plastics.

**PP** (Polypropylene) is a semi-rigid, lightweight, economical plastic with excellent chemical resistance and a fairly high service temperature. Polypropylene is available in natural (translucent white), standard and custom colors.

**PE** (Polyethylene) ranges from flexible (LDPE) to semi-rigid (HDPE). A very economical material, polyethylene is good for plastic profile extrusion applications requiring low surface resistance. It is available in both FDA and industrial grades. Polyethylene also has good chemical resistance and is available in natural (translucent white), standard and custom colors.

**TPE** (Thermoplastic Elastomers) is a collective name for several different families of elastomers that may contain differences in composition and molecular structure. Their performance properties are similar to conventional thermosets, such as EPDM or neoprene.

The important features of TPEs are their flame and ozone resistance, excellent flex fatigue and performance in alcohol. TPEs, however, are limited by their poor resistance to aliphatic and aromatic hydrocarbon solvents as well as oil and gasoline.

**PA** (Polyamide), also known as Nylon, is a resin of choice for numerous industrial and commercial applications. This thermoplastic material is resistant to wear and abrasion, exhibits good mechanical properties even at elevated temperatures, has low permeability to gases and demonstrates good chemical resistance. Polyamides are available in a wide variety of colors.



## WHY UNIFORM WALL THICKNESS MATTERS

Designing plastic profiles to have a uniform wall thickness can help prevent problems in two key stages of the extrusion process.

First, the consistent flow of material through the die is critical to ensuring that an extrusion maintains its shape. Significant variances in wall thickness can cause material to flow unevenly and lead to distortions in the profile.

The second consideration is the even cooling of a part once it exits the die.

Thicker walls and interior supports will require additional time to decrease in temperature. Proper design will prevent bowing or twisting that can occur due to these differences in cooling rates.

Cooper Standard ISG engineers can help you determine wall thickness requirements and limitations based on the complexity of the part and the chosen material.



**POOR DESIGN**



**PREFERRED DESIGN**





## AVOIDING SHARP CORNERS

Sharp corners can create a weak point in extruded plastic profiles. The result is that when a part is subjected to impact or stress, cracking is more likely to occur.

To remedy this, the radii of corners should be as large as possible given the demands of the application. This improves the strength of the final product, as well as the flow of the material during extrusion.



POOR DESIGN



PREFERRED DESIGN

Generally, the radii of outside corners should be at least  $1\frac{1}{2}$  times the wall thickness. The inside radii should be  $\frac{1}{4}$  times the wall thickness.



## SINK MARKS

Because of differences in cooling rates, sink marks can occur where two perpendicular projections are joined.

SINK MARK



A greater variation in the thickness of these projections will increase the severity of this cosmetic defect.

Sink marks can often be eliminated or hidden through careful design as shown in the examples below.

RIDGE



SERRATION



NOTCH



**Adding design features such as serrations, ridges and notches can help minimize the appearance of sink marks.**

## HOLLOW AREAS

While it is common to extrude plastic profiles with hollow sections, there are important limitations. Hollows within hollows or hollow sections that contain other design features should be avoided. The interior of the part will cool at a slower rate, preventing these sections from maintaining their shape.



## TOLERANCES

While it may be possible to meet precise specifications for plastic extrusions, achieving these tight tolerances can lead to an increase in tooling, material and production costs.

This can be due to the need for higher-grade plastic resins, slower run times or additional processes such as offline cutting.

In some cases, material properties along with complex part designs may limit the ability to hold certain tolerances.





# PLASTIC VS. RUBBER

For many applications, both plastic and rubber can be viable options for engineers. Considering both types of materials ensures you achieve the best performance for your project's needs.

A polymer expert or application engineer can help identify a material that will provide a balance of the desired properties for the end-use application.

**While there are significant differences between plastic and rubber, these materials can share many performance properties.**



PLASTIC EXTRUSION



RUBBER EXTRUSION

## WHEN TO USE PLASTIC

When a component requires hardness or rigidity, rubber is simply not able to compete with plastic materials. Rubber compounds typically can achieve a maximum durometer or Shore A rating of 90.

An important design consideration for plastics is whether the profile needs to be rigid or flexible. Rigid plastics work well for applications in which durability and impact resistance are important. Flexible plastics can be engineered to mimic the physical properties of rubber when those characteristics are desired. In many cases, flexible plastics are more lightweight than a rubber compound equivalent.

Flexible plastic materials can include PVC, Low Density Polyethylene and TPEs. Of these, TPEs are the materials most commonly used to achieve the performance properties of rubber. This family of plastics includes TPVs, TPOs and TPUs.

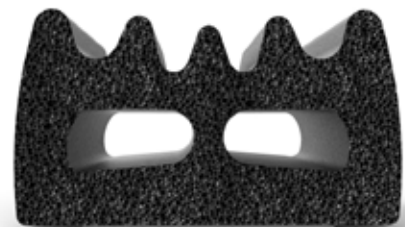


## WHEN TO USE RUBBER

Rubber is often best used in dynamic applications where compression set properties are important. Rubber also may outperform many general-use plastics in harsh operating environments.

The temperature range for silicone components, for example, can reach as high as 450° F. That is far above the range of comparable plastic materials. Likewise, EPDM is a versatile polymer that offers outstanding UV, weather and ozone resistance and is ideal for outdoor applications.

When sound and vibration dampening qualities are important, rubber is often preferred.





## JOINING PLASTIC & RUBBER

Often, an application calls for a component that has both rigid and flexible features.

For instance, a dual-durometer seal may have a rigid portion that is inserted into a channel and a flexible bulb that achieves dynamic sealing properties.

Because rubber and plastic do not have the compatibility to be coextruded, the most common solution is to combine either rigid and flexible plastic or sponge and dense rubber.

Another option is to join plastic to rubber.

Cooper Standard Industrial and Specialty Group (ISG)'s iDea® Seal products feature a sponge or dense EPDM bulb chemically bonded to a plastic base. These products can easily slide into a channel and will not stretch.

A mechanical connection may also be used to join plastic and rubber. Many times, this involves attaching a plastic extrusion to a rubber component using fasteners such as plastic rivets.

A plastic extrusion may also have a channel that allows a rubber seal to be inserted.



**A dual-durometer plastic extrusion with rigid and flexible features.**



## MAKING THE CHOICE

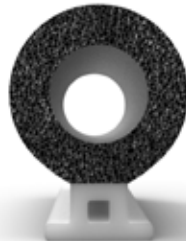
There are simply too many variables to say one material will always outperform the other. The decision will be unique to the specific conditions of each application.

For instance, it is possible that TPV could effectively replace an EPDM seal while offering lower weight or improved aesthetic qualities. On the other hand, EPDM may be the better choice to meet physical requirements such as

compression set in the end-use application.

The important thing is to not limit yourself to just rubber or plastic options based on the capabilities of a manufacturer.

Cooper Standard ISG engineers have a breadth of experience with both types of material and can help you make an informed decision.



**Options for combining sponge EPDM, dense EPDM and plastic in order to deliver added performance properties.**





## PLASTIC VS. ALUMINUM

**Rigid plastic extrusions may be more cost effective than aluminum or steel components in certain applications.**

Plastic extrusion can be more favorable than aluminum when it reduces the number of steps in manufacturing or fabrication processes.

Rigid plastic extrusions allow for efficient in-line operations such as drilling or cutting.

In some cases, multiple plastic materials are extruded together to achieve a mix of performance properties while eliminating the need for off-line assembly.

With plastic components, colored polymers are used in place of painting or powder coating, creating significant time savings.

As an added advantage, plastic produces consistent color throughout the entire part. This minimizes the appearance of potential chips or scratches that would be highly visible on a painted surface.

Replacing metal parts with rigid plastic can deliver a number of other additional benefits.

The ability to reduce the overall weight of components is an attractive feature of rigid plastic. In high-moisture applications, such as shower surrounds, plastic can provide mildew resistance. Plastic also may be the solution when anti-static properties are desired.

To determine if a custom plastic extrusion is suitable for your application, Cooper Standard ISG's engineers will work with you to consider strength, mechanical, thermal and other requirements. Part design will be evaluated based on the chosen material to ensure proper performance and manufacturing efficiency.

When key criteria are met, plastic extrusions offer an alternative to metals in a variety of markets including automotive components, clean rooms, conveyors, office furniture and more.





## EXTRUDED PLASTIC BASE IMPROVES SILICONE SEAL INSTALLATION

To help a customer minimize the use of adhesives during product assembly, Cooper Standard ISG developed an alternative method for attaching a silicone gasket.

Engineers designed a rigid plastic base that grips on to the product. To do this, a dual-durometer plastic extrusion was required.

Rigid plastic was used as a base. A channel that allows the base to slide onto the component was lined with flexible plastic "grippers." This ensured it was held firmly in place during product assembly.

The opposite side of the base features a slot that accepts the silicone gasket.

While Cooper Standard ISG frequently bonds EPDM profiles to a plastic base, the silicone compound used in this application would not adhere to plastic in the same way.

By using a mechanical connection, the manufacturer was able to take advantage of silicone's performance properties while improving the assembly process and throughput.

The need for adhesives to attach the gasket was significantly reduced, resulting in greater manufacturing efficiency.





## DIVERSE PERFORMANCE CAPABILITIES

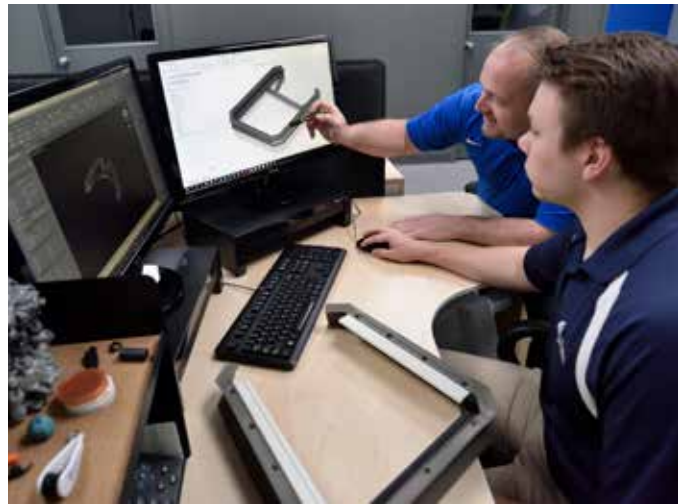
When a customer required a rainscreen gasket for a unique feature on a high-rise building, Cooper Standard ISG brought together a number of its manufacturing capabilities.

Not only did the gasket need to seal a component with multiple corners, it also served as a highly-visible design detail.

Due to the complexity of the application, a molded silicone gasket provided the solution. Rigid PVC plastic extrusions were added to the interior of the gasket using push pins. This created a method for attaching the gasket to the building component.

Silicone proved to be best material due to its high-performance and ability to be colored to match the building's design.

During the part development process, a 3-D printed prototype helped ensure that the gasket would compress properly. This was a critical feature of the part, which was required to perform under demanding conditions.



Notably, the project was made possible due to Cooper Standard ISG's diverse and integrated capabilities.

Those include custom rubber compounding, design engineering, rubber molding, rubber and plastic extrusion and part fabrication.



## GET STARTED

Our dedicated ISG team provides technical, material and product expertise, as well as extensive market and material knowledge to develop customized, high-performing solutions.

We work with you to help take your project to the next level, reviewing your industry's specific needs and the end-use conditions of your application.

Call us today to get started on your next project.

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