

DESIGN GUIDE

FORMEX™ GK

FORMEX™ GS

FORMEX™ GL

FORMEX™ N3

FLAME RETARDANT
INSULATION

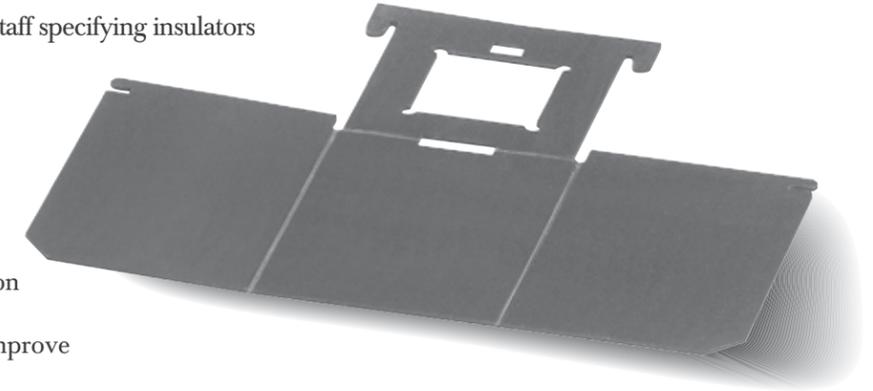
TWFormex®

TABLE OF CONTENTS

• Introduction and Overview	1
• About ITW Formex®	2
• About Illinois Tool Works	2
• Die Cutting/Types of Presses	3
• Types of Dies	3
• Design for Die Cutting	4
Blanks	5
Scores	5
Holes	6
Tabs	6
• Part Processing	7
Marking	7
Lamination	7
EMI/RFI Shielding	7
Thermoforming	8
Welding	8
Heavy Gauge Fabrication	8
Prototyping	8
• Joinery	8
• Production Information	11-14
Formex GK	11
Formex GS	12
Formex GL	13
Formex N3	14
• Sample Assembly Instructions	15

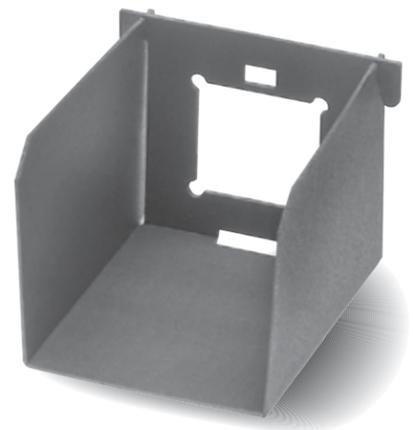
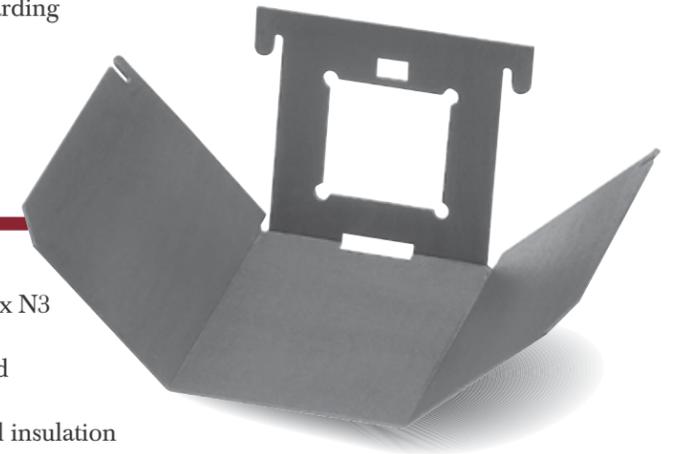
INTRODUCTION

The goal of this design guide is to provide useful and practical information to engineers, designers, and technical staff specifying insulators and other die cut parts from Formex GK, Formex GS, Formex GL and Formex N3 material(s). General process information and specific design suggestions help improve functionality, quality and durability of the product. This booklet is intended to provide guidance and not establish definitive rules. Please consult your fabricator or die cutter regarding the specifics of any design.



OVERVIEW

Formex GK, Formex GS, Formex GL and Formex N3 are flame retardant grades of polymer, extruded into sheet and primarily used for their electrical insulation properties. These materials meet the insulation requirements for most applications due to their high dielectric strength, low moisture absorption and UL 94V-0 flame class rating. Formex insulation provides exceptional scoring and bending characteristics resulting in superior folded parts. For the purposes of this guide all Formex Products: Formex GK, Formex GS, Formex GL and Formex N3 can be processed identically.



ITW Formex® is a global manufacturer of innovative electrical insulating materials for electronics manufacturing and high voltage electrical applications. The company has 30 years experience in providing Formex™ electrical insulating materials for use in a wide variety of applications ranging from automotive batteries to industrial equipment and consumer electronics applications. No other flame retardant electrical insulation can equal the performance and versatility of Formex™ products for cost-effective fabricated parts. Many engineers have cut significant cost from their designs by replacing a variety of injected molded parts, electrical papers and thermoplastic materials. Formex™ Insulation Materials are highly engineered to serve the demands of sophisticated applications efficiently. Headquartered near Chicago, ITW Formex® provides technical and sales assistance, distribution and production globally.

ABOUT ILLINOIS TOOL WORKS (ITW)

ITW businesses serve local customers and markets around the globe, with a significant presence in developed as well as emerging markets. The company has operations in 57 countries that employ more than 50,000 women and men who adhere to the highest ethical standards. These talented individuals, many of whom have specialized engineering or scientific expertise, contribute to our global leadership in innovation. We are proud of our broad portfolio of more than 17,000 granted and pending patents.

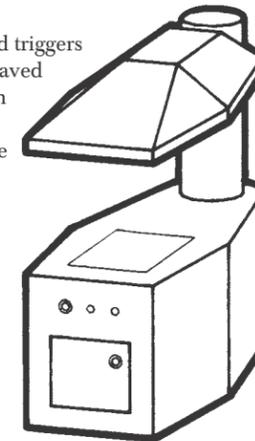
Die cutting is the transfer of pressure through hardened steel dies to softer material in order to cut, score or crease the material into desired shapes or patterns. The most common variables in this process are the press type and die type. The part fabricator's selection is based on equipment availability, material properties, thickness, part geometry, tolerance and required volume, as well as personal experience.

TYPES OF PRESSES

There are three main press types for die cutting use, each having its own advantages. Presses can be automatic or manually operated, use roll or sheet stock, and can handle several types of die cutting tools. Part size, scoring accuracy and processing speed will vary with the type of equipment, however most parts can be processed on any of these machines. Some parts lend themselves to a particular press type due to part size, tolerance, run volumes, die types, etc.

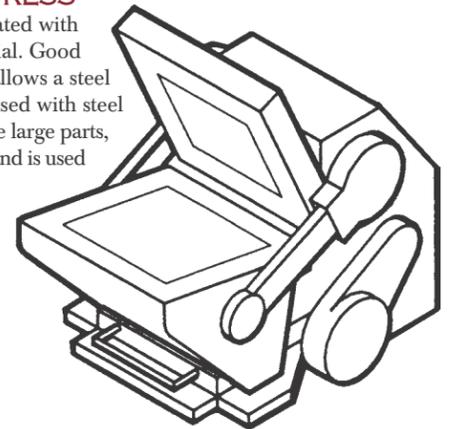
CLICKER PRESS

Operator feeds material, places die and triggers press. Can accommodate forged, engraved or steel rule dies. A nylon lower platen compensates the limited leveling capability of the press. Material may be cut from roll or sheet stock.



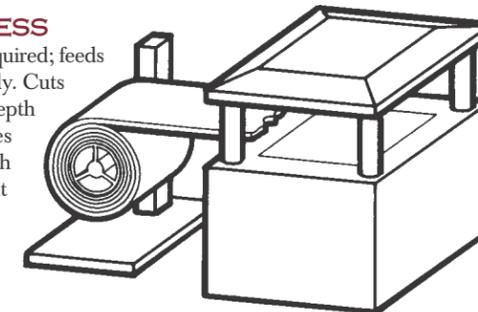
CLAMSHELL PRESS

Automatically operated with manually fed material. Good leveling capability allows a steel lower platen to be used with steel rule dies. Can handle large parts, requires sheet stock and is used for larger volume processing.



AUTOMATIC PRESS

Operator not always required; feeds and cycles automatically. Cuts steel to steel for good depth accuracy. Primarily uses roll stock, good for high volume runs, can count and prepackage parts.



TYPES OF DIES

STEEL RULE DIES

The steel rule die is the most common due to its versatility. Steel rule dies can be used on most presses, can be hand-placed or platen-mounted and are the most economical. (See page 4)

FORGED DIES

Made from a tapered steel band, sharpened at the edge which is cut, shaped, and welded into position. They are also moderately priced, capable of close tolerances and are uniquely suited to thicker stock.

ENGRAVED DIES

Made from a steel block with material etched away to form cutting edges. They are moderately priced, can hold close tolerances and are capable of unique shapes.

MALE/FEMALE DIES

Similar to metal stamping dies. Capable of producing close tolerance features and intricate part designs. Male/female dies are usually used in high volume applications where their cost is justified.

A steel rule die consists of a hardwood base with sharpened steel blades, or rule inserted and connected in a pattern. Different techniques of assembling the punches, blades, ejection, and other die components may be used to accommodate the various characteristics required for each part. Designs which take into consideration the strengths and weaknesses of this die system produce failure-free parts economically.

Steel rule serves two functions; to cut material completely through or to score the material for folding. Center and side bevel rule is used for full or partial cutting. Creasing rule is used to provide a score line without cutting material. The perforating rule is used for “perf” scoring, which is preferred in certain applications. Die construction details are usually specified by the die maker and the part fabricator. Multiple cavity dies are available for higher volume production.

HARDWOOD BASE

Multiple layers of birch or maple provide a tough, shock absorbent, warp resistant base. Grooves cut into the base accept steel rule which is either straight length or hand-bent.

PUNCHES

Inserted into base to form internal cutouts. Available in standard shapes and sizes (round, square or oval) and custom shapes and sizes.

LOWER RULE

Set slightly lower than cutting rule. Used to score or crease material for folding.

RUBBER EJECTION STRIP

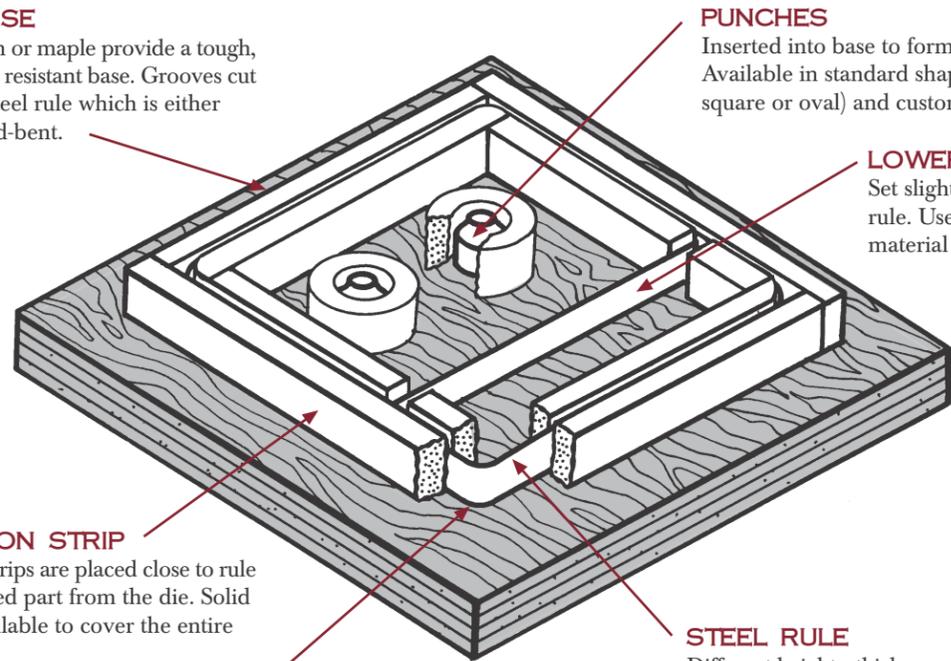
Self-adhesive rubber strips are placed close to rule to help remove finished part from the die. Solid rubber ejection is available to cover the entire cavity, if required.

RADIUS CORNER

Formed by bending a single rule; radius can vary.

STEEL RULE

Different heights, thicknesses and edge treatments provide all linear cutting and scoring/creasing. Rule used to completely cut out any part of the material are set to one height.



DESIGN FOR DIE CUTTING

Die cut parts have four basic elements: blanks, scores, holes and tabs. These features can usually be formed simultaneously.

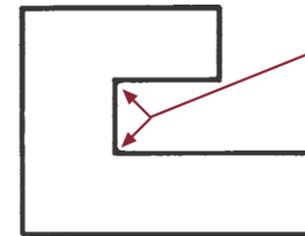
Optimal part design for die cutting involves a balance between specific features and manufacturing economies.

Design parameters take into consideration the following:

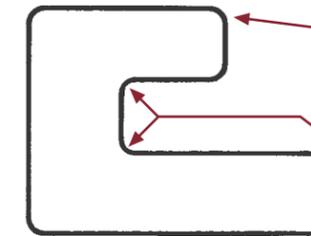
- Lower tool costs and lead times through the use of standard rule and punch components
- Unnecessary features/detail which reduce throughput
- Inappropriate tolerance levels
- Ease of manufacturing

BLANKS

Blanks are formed by a full depth rule cut which separates the part (blank) from the remaining stock.

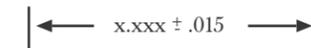


Avoid sharp internal/external corners which promote cracking or splitting of material.



Rounded external corners increase die strength and service life. Additional benefits include faster production, prevention of cracks, corner splits and burrs.

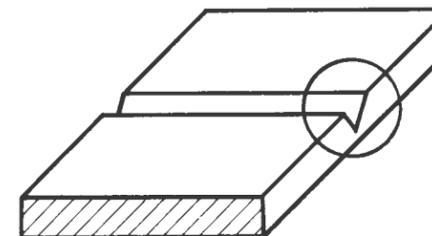
Minimum radius should be 0.031" for material less than 0.031" thick. Consult part fabricator for radius minimums for material greater than 0.031".



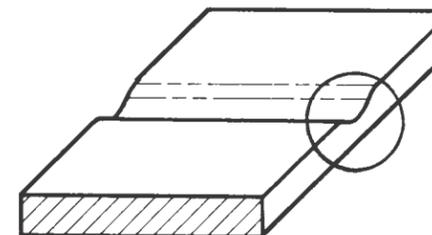
Note: General tolerance shown. Consult your fabricator for more detailed information.

SCORES

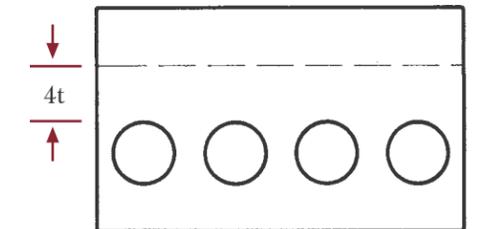
Scores are formed by cutting or creasing the blank. This establishes a line along which the part can be easily and accurately folded.



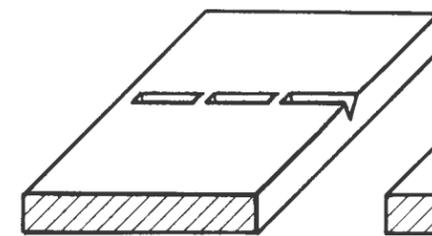
CUT SCORES are a partial depth cut. Depth should be controlled; deep cuts cause material to tear, and shallow cuts result in inaccurate folding.



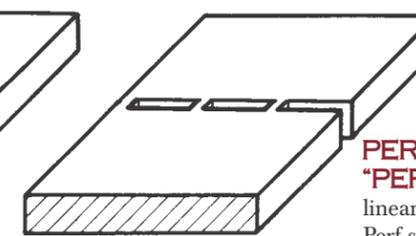
CREASE SCORES do not cut but “upset” or thin the material. Consequently, depth is not as critical as with cut scores.



A series of holes must be kept at a minimum distance from a score line to prevent the part from folding through the holes. Four material thicknesses is the recommended minimum.



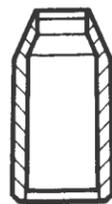
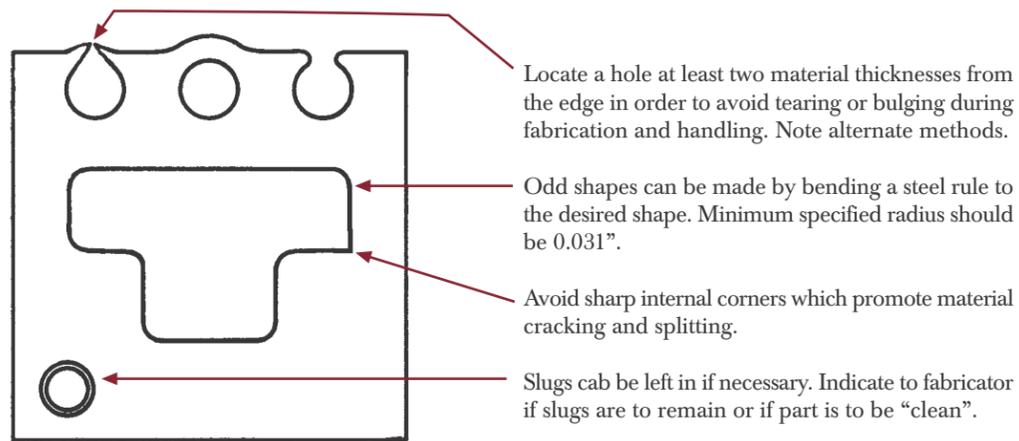
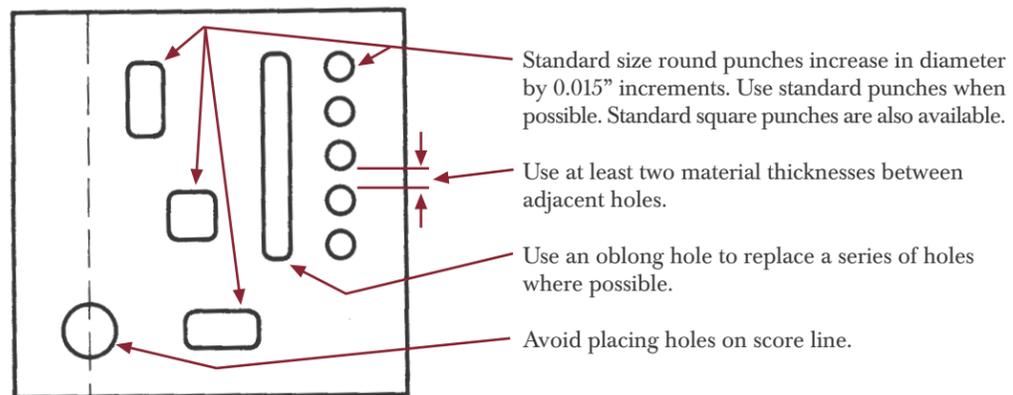
Partial Perf Score



Full Perf Score

PERFORATED OR “PERF” SCORES are a series of linear slits similar to paper perforations. Perf scores may be full or partial depth.

Holes can be produced in the blank in virtually any shape using standard and special punches and rule formed to the desired shape.



Some punches, predominately the self-ejecting type, have larger diameter bases than the holes they produce. Check with part fabricator to determine the minimum distance between centers.

TABS

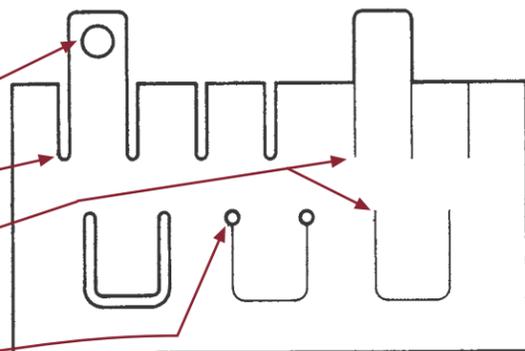
Part design may include tabs for various reasons. Often they are to accommodate an attachment feature. Internal tabs are completely enclosed within the part; external tabs are located along an outside edge.

When putting holes in tabs, provide a minimum of two material thicknesses around the holes.

Provide a slot completely around the tab, if possible.

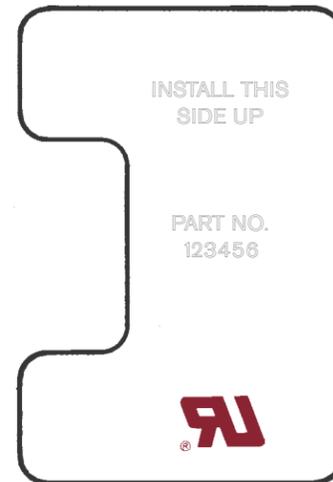
Tab cuts should **not** be terminated with bare rule end. The resulting stress riser can cause cracking or tearing.

Internal tabs should be terminated with holes to dissipate stress.



MARKING

Die cut parts may need to be marked for product identification, coding or to provide safety related and/or technical information. Simple requirements such as a part or code numbers may be embossed during die cutting or hand-stamped later. More extensive information may require some form of printing, such as one of the following:



Note: Formex GK materials have been specifically produced to accept printing inks. If product has become dirty during fabrication, printing quality can be maintained by cleaning the part with pure isopropyl alcohol prior to printing.

LAMINATION

Additional properties can be obtained by laminating other materials to Formex GK, Formex GL, Formex N3 and Formex GS. An example of this is the lamination of aluminum or copper foil to provide EMI/RFI shielding. Lamination with a pressure sensitive adhesive is the most common way of producing a multilayered part. The best results will be achieved by using a soft or cross-linked acrylic adhesive. Acrylic adhesives are commonly used due to their proven long-term holding power and resistance to cold flow and outgassing.

A variety of adhesive tapes are available for specific applications such as laminating, mounting and positioning. Foam-backed tapes can be used where mounting surfaces are uneven.

EMI/RFI SHIELDING

Shielding against electromagnetic and radio frequency interference (EMI/RFI) may be accomplished using a Formex GK, Formex GL, Formex N3 and Formex GS metal foil laminate. This lamination provides the unique combination of a superior insulator coupled with an EMI/RFI shield. While Formex products may be laminated to different metal foils,

HOT STAMPING

A pigmented transfer film is pressed against the part using a heated platen which transfers the pigment to the part.

SILK SCREENING

Ink is pressed through a selectively-coated screen of fine fabric onto the part. Durability is enhanced by using ink specifically formulated for polypropylene.

PAD PRINTING

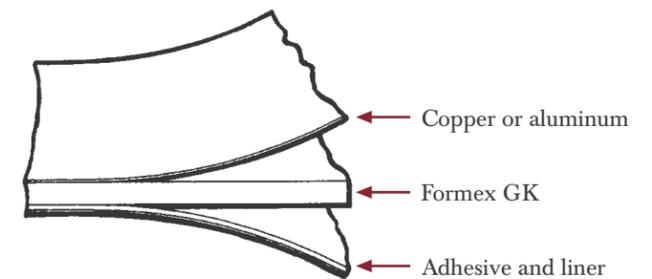
Ink is transferred to the part from an etched platen via a silicone pad. Epoxy inks are recommended for sharpness and quality.

FLEXOGRAPHIC PRINTING

A high-speed ink transfer method typically used in high volume printing applications where material is printed prior to die cutting.

EMBOSSED PRINTING

Standard marking punches used to impress identification marks into the material during die cutting is most economical. Custom punches can be fashioned for special characters or symbols.



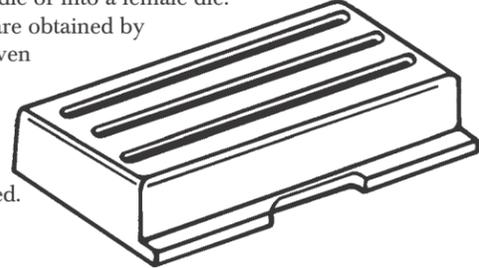
Note: Formex GK, Formex GL, Formex N3 and Formex GS materials have been specifically produced to accept adhesives. Adhesive performance will be improved by maintaining surface cleanliness. Pure isopropyl alcohol may be used for this purpose if required.

2.0 mil dead soft aluminum and copper are economic and widely available. Shielding effectiveness of any system is a function of many different variables. Most applications use aluminum or copper which are proven performers. Ferrous based foils have found acceptance in low frequency magnetic shielding applications.

THERMOFORMING

Thermoforming produces three dimensional parts without scoring and folding. It is accomplished by applying sufficient heat to the material for subsequent drawing over a male die or into a female die.

Best results are obtained by using slow even heating. A preheat cycle prior to final heating is recommended.

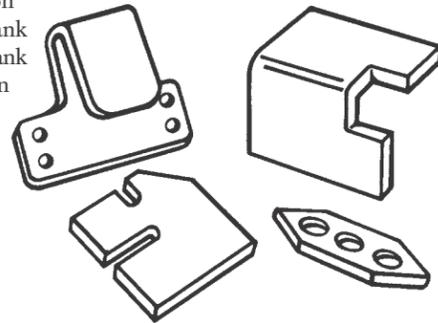


WELDING

Thermal bonding involves bringing the material to its melt temperature, fusing the pieces together and cooling. Heating may be achieved using hot air, resistance heaters, or friction as in the case of ultrasonic welding. Benefits of heat bonding include extremely strong joints as well as self-contained fastening.

HEAVY GAUGE FABRICATION

Heavy gauge material is often formed using a sheet metal brake or forming mixture. The material may be fabricated cold or with the assistance of heat. Strip heaters are used to concentrate heat on the portion of the blank being formed. The blank may also be heated in its entirety prior to forming in a fixture.



PROTOTYPING

Many times prototype parts or small quantities of pilot run parts are required during the early stages of a project. The use of laser or water jet cutting provides very accurate parts in a fraction of the time required for conventional prototyping. Fabricators can often have prototype parts available within the same day they were requested, particularly when electronic part files are utilized.

JOINERY

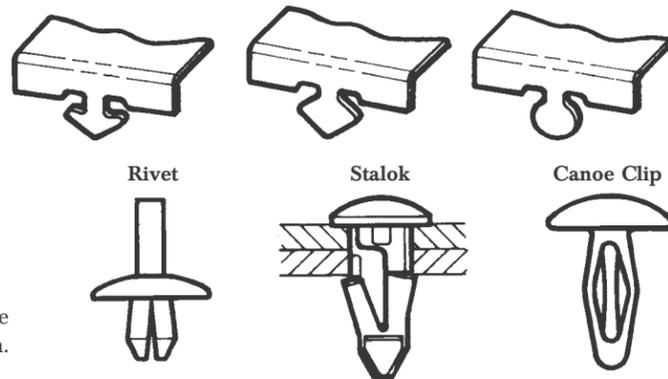
Several methods for fastening and joining exist which facilitate assembly. The following pages illustrate examples.

SELF-CONTAINED

Self-contained fasteners are integral to the design of the part and require no external devices. Economic benefits are achieved by eliminating stock, handling and assembly costs.

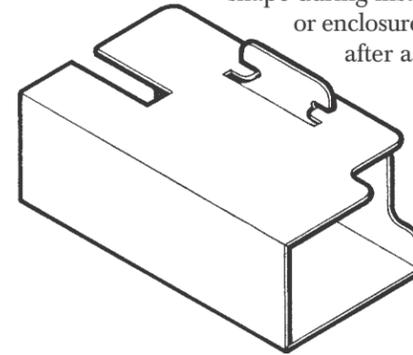
EXTERNAL FASTENERS

External fasteners may be required when design parameters prevent self-contained fastening. These fasteners need not be limited to conventional screws and nuts. A wide variety of products are available which will provide the secure attachment of the part in its application.

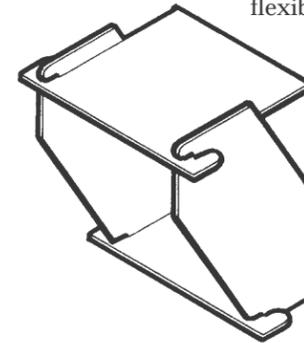


JOINERY EXAMPLES

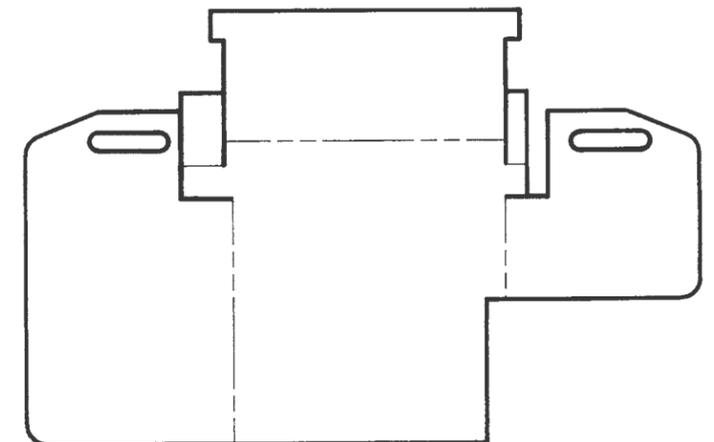
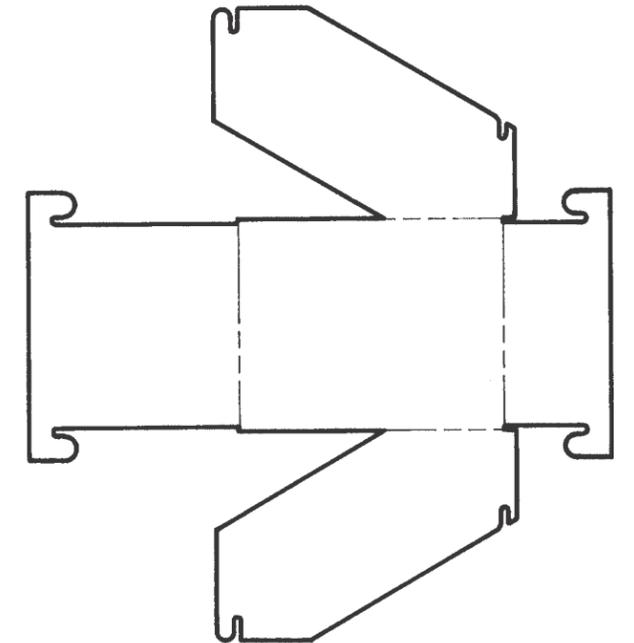
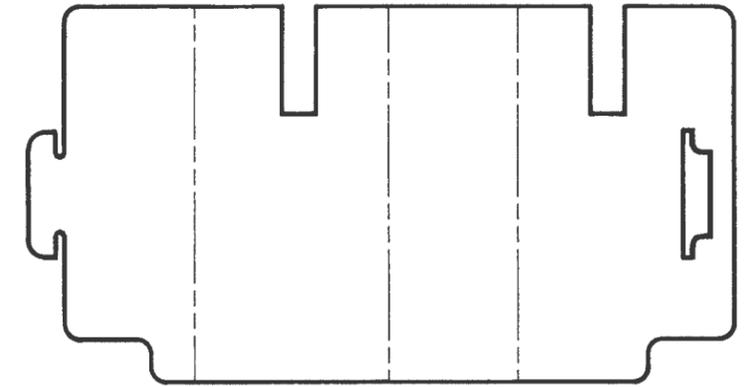
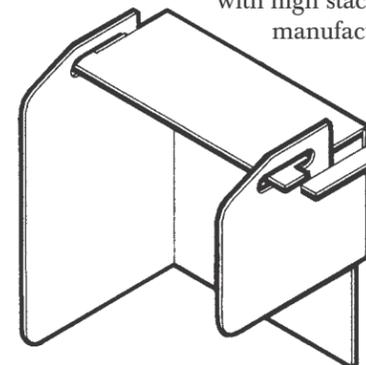
Simple tabs can be used to hold a part in shape during installation. A chassis or enclosure may hold the part after assembly.



These interlocking corners rely on material flexibility and memory.



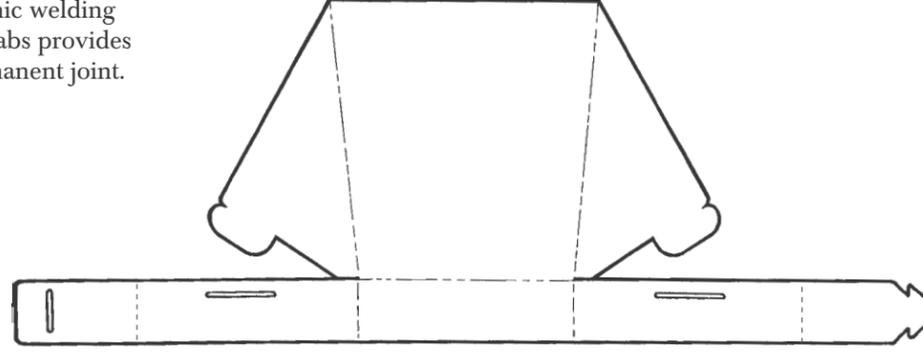
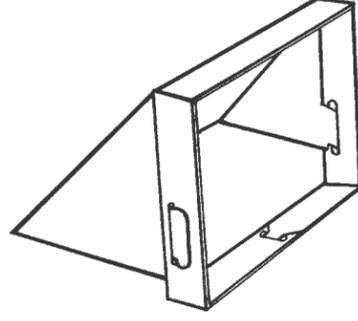
Loose fitting parts can adapt to assemblies with high stack tolerances allowing manufacturing flexibility.



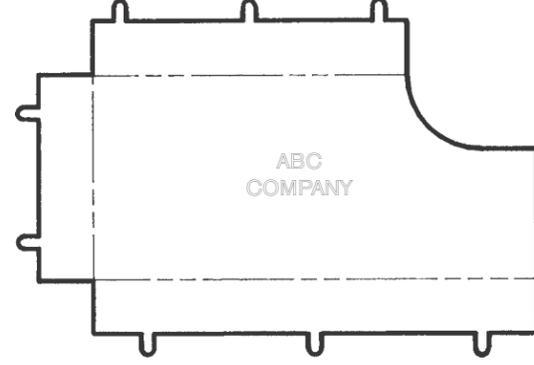
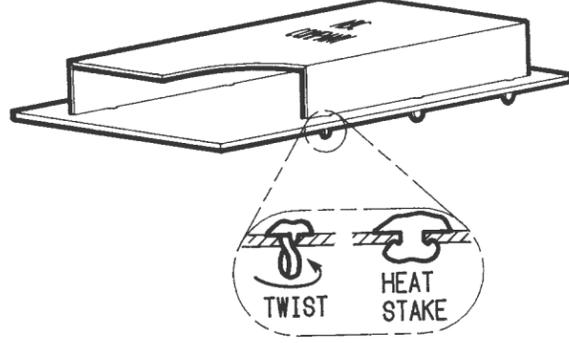
JOINERY EXAMPLES



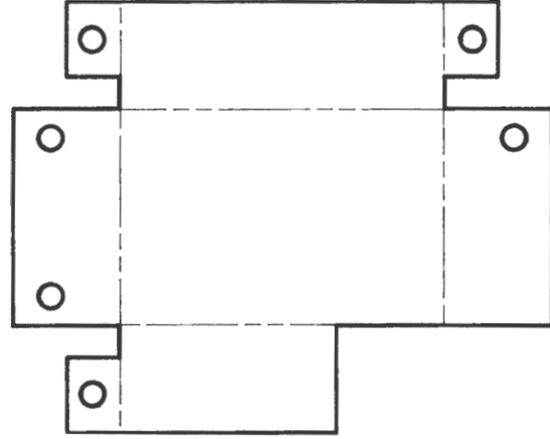
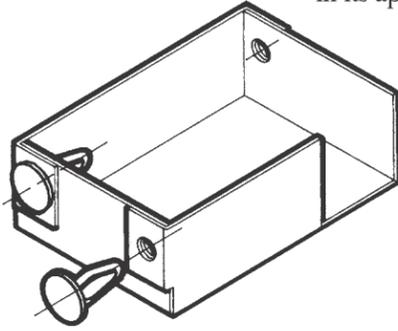
Simple tabs allow parts to be assembled and disassembled if necessary. Heat staking or ultrasonic welding these tabs provides a permanent joint.



Tabs may be twisted to upset the material or heat staked to provide a permanent installation. When used on PC board applications these tabs require little "real estate".



External fasteners can be used to hold the part together as shown or to retain the part in its application.



ITW Electronic Components FORMEX
425 North Gary Ave.
Carol Stream, IL 60188
Phone: 630-315-2171
Website: www.itwformex.com



FORMEX™ GK PRODUCT DATA FLAME RETARDANT POLYPROPYLENE SHEET

	TEST METHOD	FORMEX GK-5	FORMEX GK-10	FORMEX GK-17	FORMEX GK-30	FORMEX GK-40	FORMEX GK-62
		Black	Natural & Black	Natural & Black	Natural & Black	Natural & Black	Natural & Black
MANUFACTURING SPECIFICATION							
Thickness							
inches		0.005 (+0.001 / -0.001)	0.010 (+0.003 / -0.0015)	0.017 (+0.003 / -0.001)	0.030 (+0.002 / -0.002)	0.040 (+0.002 / -0.002)	0.062 (+0.004 / -0.004)
millimeters		0.127 (+0.025 / -0.025)	0.25 (+0.08 / -0.04)	0.43 (+0.08 / -0.03)	0.76 (+0.05 / -0.05)	1.02 (+0.05 / -0.05)	1.57 (+0.10 / -0.10)
UL FLAMMABILITY RATING / PERFORMANCE LEVELS							
Flammability	UL 94	VTM-0	VTM-0	V-0	V-0	V-0	V-0
Relative Temperature Index	UL 746B						
Electrical		115°C / 239°F	115°C / 239°F	115°C / 239°F	115°C / 239°F	115°C / 239°F	115°C / 239°F
Mechanical Without Impact		115°C / 239°F	115°C / 239°F	115°C / 239°F	115°C / 239°F	115°C / 239°F	115°C / 239°F
High Current Arc Ignition - PLC (arcs to ignite)	UL 746A	0	0	0	0	0	0
High Voltage Arc Tracking - PLC (in / min)	UL 746A	0	0	0	0	0	0
Hot Wire Ignition - PLC (seconds)	UL 746A	4	4	4	4	4	4
Comparative Tracking Index - PLC	ASTM D-3638	0	0	0	0	0	0
TYPICAL MECHANICAL PROPERTIES VALUES							
Tensile Yield - psi	ASTM D-882 / ISO 527-1,-2	3,700	4,400	4,400	4,000	4,000	4,000
Machine Direction		3,000	3,200	3,200	3,200	3,700	3,700
Transverse Direction							
TYPICAL PHYSICAL PROPERTIES VALUES							
Density - gm/cc	ASTM D-792 / ISO 1183-1, Method A	1.035	1.035	1.035	1.035	1.035	1.035
Oxygen Index - %	ASTM D-2863 / ISO 4589--1,-2	29	29	29	29	29	29
Water Absorption - % Change in weight	ASTM D-570 / ISO 62, Method 4	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%
Heat Deflection Temperature under load	ASTM D-648 0.45MPa / ISO 75-1,-2, Method B	121°C / 250°F	121°C / 250°F	121°C / 250°F	121°C / 250°F	121°C / 250°F	121°C / 250°F
Surface Energy - dynes / cm (as produced)	ASTM D-2578	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50
TYPICAL ELECTRICAL PROPERTIES VALUES							
Comparative Tracking Index - volts	IEC 60112	600	600	600	600	600	600
Dielectric Breakdown - volts	ASTM D-149 / IEC 60243-1	11,000	16,264	20,292	29,610	33,380	41,558
Dielectric Strength - volts / mil	ASTM D-149 / IEC 60243-1	2,200	1,626	1,194	987	834	670
Volume Resistivity - ohm-cm	ASTM D-257 / IEC 62631-3-1	3.97 x 10 ¹⁵	3.97 x 10 ¹⁵	3.97 x 10 ¹⁵	3.97 x 10 ¹⁵	3.97 x 10 ¹⁵	3.97 x 10 ¹⁵
Dielectric Constant	ASTM D-150 / IEC 60250, 1MHz	1.90	1.90	1.90	1.90	1.90	1.90
Dissipation Factor	ASTM D-150 / IEC 60250, 1MHz	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
PACKAGING INFORMATION							
Standard Configuration		Roll	Roll	Roll	Roll & Sheet	Sheet	Sheet
Core ID - inches (millimeters)		6 (152)	6 (152)	6 (152)	6 (152)	-	-
Roll OD - inches (millimeters) (approximate)		11 (289)	18 (457)	18 (457)	18 (457)	-	-
Roll Width - inches (millimeters)		24 (610)	24 (610)	24 (610)	24 (610)	-	-
Roll Weight - lbs (kgs) (approximate)		57 (26)	198 (90)	178 (81)	192 (87)	-	-
Length/Roll - feet (meters)		1,000 (304.8)	2,000 (609.6)	1,000 (304.8)	600 (182.9)	-	-
Area/Roll - square feet (square meters)		2,000 (185.8)	4,000 (371.6)	2,000 (185.8)	1,200 (111.5)	-	-
Area/Roll - square feet (square meters)		-	-	-	24 x 48 (610 x 1.219)	24 x 48 (610 x 1.219)	24 x 48 (610 x 1.219)

Notice: The above data is believed to be accurate and reliable. ITW assumes no responsibility for end-use application, and no performance warranty is expressed or implied. Formex is a registered trademark of ITW. GK is the specific name of our product. Others can not use it without our permission.



E121855

For a complete listing of Formex products, contact your Formex sales representative.



ITW Electronic Components FORMEX
425 North Gary Ave.
Carol Stream, IL 60188
Phone: 630-315-2171
Website: www.itwformex.com

FORMEX™ GS PRODUCT DATA

FLAME RETARDANT POLYPROPYLENE SHEET

TEST METHOD		FORMEX™ GS-10	FORMEX™ GS-17	FORMEX™ GS-30
		Natural *	Natural *	Natural *
MANUFACTURING SPECIFICATION				
Thickness				
inches		0.010 (+0.003 / -0.0015)	0.017 (+0.003 / -0.001)	0.030 (+0.002 / -0.002)
millimeters		0.25 (+0.08 / -0.04)	0.43 (+0.08 / -0.03)	0.76 (+0.05 / -0.05)
UL FLAMMABILITY RATING / PERFORMANCE LEVELS				
Flammability		UL 94	VTM-0	V-0
Relative Temperature Index		UL 746B		
Electrical		115°C / 239°F	115°C / 239°F	115°C / 239°F
Mechanical Without Impact		115°C / 239°F	115°C / 239°F	115°C / 239°F
High Current Arc Ignition - PLC (arcs to ignite)		0	0	0
High Voltage Arc Tracking - PLC (in / min)		0	0	0
Hot Wire Ignition - PLC (seconds)		4	4	4
Comparative Tracking Index - PLC		ASTM D-3638	0	0

TYPICAL MECHANICAL PROPERTIES VALUES				
Tensile Yield - psi		ASTM D-882 / ISO 527-1,-2		
Machine Direction		4,400	4,400	4,000
Transverse Direction		3,200	3,200	3,200

TYPICAL PHYSICAL PROPERTIES VALUES				
Density - gm / cc		ASTM D-792 / ISO 1183-1, Method A		
Oxygen Index - %		1.035	1.035	1.035
Water Absorption - % Change in weight		29	29	29
Heat Deflection Temperature at 66 psi		0.06%	0.06%	0.06%
		ASTM D-570 / ISO 62, Method 4		
		ASTM D-648 0.45MPa / ISO 75-1,-2, Method B		

TYPICAL ELECTRICAL PROPERTIES VALUES				
Comparative Tracking Index - volts		600	600	600
Surface Resistivity - ohms / square		10 ⁹ -10 ¹¹	10 ⁹ -10 ¹¹	10 ⁹ -10 ¹¹
Dielectric Breakdown - volts		16,830	19,610	26,480
Dielectric Strength - volts / mil		1,683	1,154	883
Volume Resistivity - ohm-cm		8 x 10 ¹⁵	8 x 10 ¹⁵	8 x 10 ¹⁵
Dielectric Constant		2.3	2.3	2.3
Dissipation Factor		0.0019	0.0019	0.0019

PACKAGING INFORMATION				
Standard Configuration		Roll	Roll	Roll
Core ID - inches (millimeters)		6 (152)	6 (152)	6 (152)
Roll OD - inches (millimeters) (approximate)		18 (457)	18 (457)	18 (457)
Roll Width - inches (millimeters)		24 (610)	24 (610)	24 (610)
Roll Weight - lbs (kgs) (approximate)		225 (102.1)	178 (81)	192 (87)
Length / Roll - feet (meters)		2,000 (609.6)	1,000 (304.8)	600 (182.9)
Area / Roll - square feet (square meters)		4,000 (371.6)	2,000 (185.8)	1,200 (111.5)

Notice: The above data is believed to be accurate and reliable. ITW assumes no responsibility for end-use application, and no performance warranty is expressed or implied. Formex is a registered trademark of ITW. GS is the specific name of our product. Others can not use it without our permission.



For a complete listing of Formex products, contact your Formex sales representative.



FORMEX™ GL PRODUCT DATA

FLAME RETARDANT POLYPROPYLENE SHEET

ITW Electronic Components FORMEX
425 North Gary Ave.
Carol Stream, IL 60188
Phone: 630-315-2171
Website: www.itwformex.com

TEST METHOD		FORMEX™ GL-10	FORMEX™ GL-17
		Natural & Black	Natural & Black
MANUFACTURING SPECIFICATION			
Thickness			
inches		0.010 (+0.003 / -0.0015)	0.017 (+0.003 / -0.001)
millimeters		0.25 (+0.08 / -0.04)	0.43 (+0.08 / -0.03)
UL FLAMMABILITY RATING / PERFORMANCE LEVELS			
Flammability		VTM-0	V-0
Relative Temperature Index		UL 94	
Electrical		UL 746B	
Mechanical Without Impact		125°C / 257°F	125°C / 257°F
High Current Arc Ignition - PLC (arcs to ignite)		115°C / 239°F	115°C / 239°F
High Voltage Arc Tracking - PLC (in / min)		2	2
Hot Wire Ignition - PLC (seconds)		0	0
Comparative Tracking Index - PLC		0	0
		ASTM D-3638	
TYPICAL MECHANICAL PROPERTIES VALUES			
Tensile Yield - psi		ASTM D-882 / ISO 527-1,-2	
Machine Direction		5,000	4,300
Transverse Direction		2,900	3,100

TYPICAL PHYSICAL PROPERTIES VALUES			
Density - gm/cc		ASTM D-792 / ISO 1183-1, Method A	
Oxygen Index - %		0.972	0.972
Water Absorption - % Change in weight		29	29
Heat Deflection Temperature at 66 psi		0.06%	0.06%
Surface Energy - dynes / cm (as produced)		ASTM D-570 / ISO 62, Method 4	
		ASTM D-648 0.45MPa / ISO 75-1,-2, Method B	
		ASTM D-2578	

TYPICAL ELECTRICAL PROPERTIES VALUES			
Comparative Tracking Index - volts		600	600
Dielectric Breakdown - volts		18,799	20,837
Dielectric Strength - volts / mil		1,880	1,226
Volume Resistivity - ohm-cm		1 x 10 ¹⁶	1 x 10 ¹⁶
Dielectric Constant		1.80	1.80
Dissipation Factor		0.0017	0.0017

PACKAGING INFORMATION			
Standard Configuration		Roll	Roll
Core ID - inches (millimeters)		6 (152)	6 (152)
Roll OD - inches (millimeters) (approximate)		18 (457)	18 (457)
Roll Width - inches (millimeters)		24 (610)	24 (610)
Roll Weight - lbs (kgs) (approximate)		192 (87)	172 (78)
Length/Roll - feet (meters)		2,000 (609.6)	1,000 (304.8)
Area/Roll - square feet (square meters)		4,000 (371.6)	2,000 (185.8)

Notice: The above data is believed to be accurate and reliable. ITW assumes no responsibility for end-use application, and no performance warranty is expressed or implied. Formex is a registered trademark of ITW. GL is the specific name of our product. Others can not use it without our permission.



For a complete listing of Formex products, contact your Formex sales representative.

FORMEX™ N3 PRODUCT DATA FLAME RETARDANT POLYCARBONATE SHEET

TEST METHOD		FORMEX™ N3-8	FORMEX™ N3-10
Color		Natural & Black	Natural & Black
MANUFACTURING SPECIFICATION			
Thickness			
inches		0.008 (+0.001 / -0.001)	0.010 (+0.0015 / -0.0015)
millimeters		0.20 (+0.03 / -0.03)	0.25 (+0.04 / -0.04)
UL FLAMMABILITY RATING / PERFORMANCE LEVELS			
Flammability	UL 94	VTM-0	VTM-0
Relative Temperature Index	UL 746B		
Electrical		130°C / 266°F	130°C / 266°F
Mechanical Without Impact		130°C / 266°F	130°C / 266°F
High Current Arc Ignition - PLC (arcs to ignite)	UL 746A	1	1
High Voltage Arc Tracking - PLC (in / min)	UL 746A	1	1
Hot Wire Ignition - PLC (seconds)	UL 746A	4	4
Comparative Tracking Index - PLC	ASTM D-3638	3	3
Furnished As		Multiple layers of sheets	Multiple layers of sheets
Voltage Meets Mandrel Test, VAC	IEC 60950-1	7,000	7,000
TYPICAL MECHANICAL PROPERTIES VALUES			
Tensile Yield - psi	ASTM D-882 / ISO 527-1,-2		
Machine Direction		7,200	7,200
Transverse Direction		6,900	6,900
TYPICAL PHYSICAL PROPERTIES VALUES			
Density - gm / cc	ASTM D-792 / ISO 1183-1, Method A	1.21	1.21
Oxygen Index - %	ASTM D-2863 / ISO 4589--1,-2	29	29
Water Absorption - % Change in weight	ASTM D-570	0.24%	0.24%
	ISO 62, Method 4	0.14%	0.14%
Heat Deflection Temperature under load	ASTM D-648 0.45MPa / ISO 75-1,-2, Method B	140°C / 284°F	140°C / 284°F
TYPICAL ELECTRICAL PROPERTIES VALUES			
Comparative Tracking Index - volts	IEC 60112	175	175
Dielectric Breakdown - volts	ASTM D-149 / IEC 60243-1	16,029	17,587
Dielectric Strength - volts / mil	ASTM D-149 / IEC 60243-1	2,004	1,759
Volume Resistivity - ohm-cm	ASTM D-257 / IEC 62631-3-1	1.2 x 10 ¹⁶	1.2 x 10 ¹⁶
Dielectric Constant	ASTM D-150 / IEC 60250, 1MHz	2.22	2.22
Dissipation Factor	ASTM D-150 / IEC 60250, 1MHz	0.0072	0.0072
PACKAGING INFORMATION			
Standard Configuration		Roll	Roll
Core ID - inches (millimeters)		6 (152)	6 (152)
Roll OD - inches (millimeters) (approximate)		17 (432)	17 (432)
Roll Width - inches (millimeters)		24 (610)	24 (610)
Roll Weight - lbs (kgs) (approximate)		202 (92)	220 (100)
Length / Roll - feet (meters)		2,000 (609.6)	1,750 (533.4)
Area / Roll - square feet (square meters)		4,000 (371.6)	3,500 (325.2)

Notice: The above data is believed to be accurate and reliable. ITW assumes no responsibility for end-use application, and no performance warranty is expressed or implied. Formex is a registered trademark of ITW. N3 is the specific name of our product. Others can not use it without our permission.



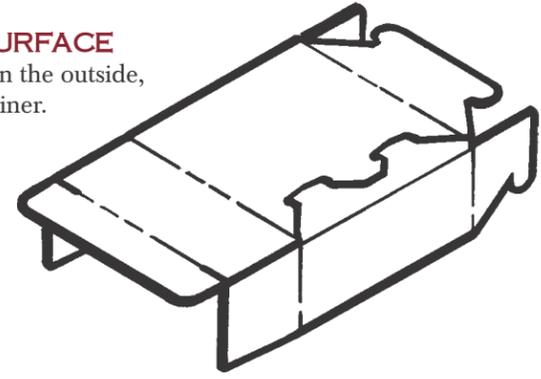
E121855

For a complete listing of Formex products, contact your Formex sales representative.

SAMPLE ASSEMBLY INSTRUCTIONS

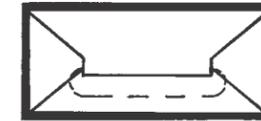
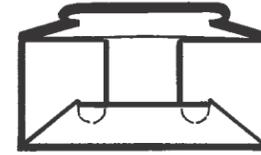
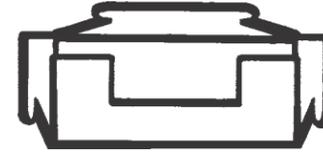
DETERMINING THE OUTSIDE SURFACE

All folds will have the score ("v" groove) on the outside, placing the hinge to the inside of the container.



FORMING THE SIDE WALLS OF THE CONTAINER

Push the two tabs into their respective slits closing the side walls.

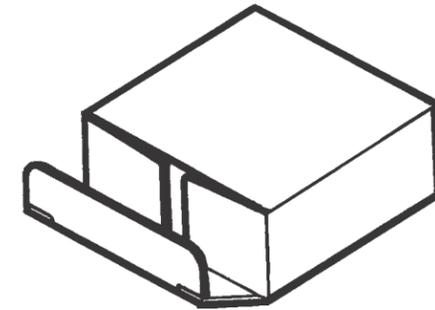


BOTTOM ASSEMBLY

1. Fold bottom flap up and side flaps out.
2. Fold side flaps inward, making sure tabs are caught securely behind notched section in bottom flap.
3. Fold top over side flaps securing its tabs between side and bottom flaps.

CLOSURE

Fold the side flaps in and close in conventional manner.



The data listed herein fall within the normal range of product properties but they should not be used to establish specification limits nor used alone as the basis of design. ITW assumes no obligation or liability

for any advice furnished by it or the results obtained with respect to these products. All such advice is provided gratis and Buyer assumes sole responsibility for results obtained in reliance thereon.



425 N. Gary Avenue
Carol Stream, IL 60188
Phone: 630.315.2171
Website: www.itwformex.com