EQUIPMENT PROTECTION
THE MAGAZINE OF ENCLOSURES AND PROTECTION
Acoustic • Contamination • EMI/ESD • Power • Shock/Vibration • Thermal
www.EquipmentProtectionMagazine.com
Serving OEM Design Engineers, Product Development Professionals, Managers and Integrators of Equipment Protection Technologies and Testing.
Summer 2004
Volume 2, Issue 3
a webcom publication

Plastic Enclosures Now Offer Cost-Effective Solutions for a Wider Variety of Applications

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Sometimes an engineer's decision to use a plastic enclosure is clear-cut, for example when the installation will be in a paper mill, where chemical attack will rapidly destroy a metal enclosure. In other instances, the decision to go with plastic is less obvious, and depends upon the severity of the installation environment.

Cost has always been a factor in selecting a plastic enclosure over a traditional metal unit. In the harshest environments, plastic generally is cost effective compared with stainless steel or high solids epoxy coated metal. For less demanding environments, painted metal was often a less costly solution, even though its corrosion resistance was not ideal. However, modern injection and compression molding techniques, coupled with the availability of high performance plastics, have dramatically improved the price-performance level of plastic enclosures, so much so that today, plastic can be considered for packaging in environments that are only moderately hostile.

But that does not mean the designer can be any less particular during the selection process. To acquire the correct plastic enclosure, the user must consider a number of factors that relate to the application. Let's take a look at each of them in some detail.

Enclosure Size

Size is the single most important factor in selecting an enclosure, particularly if it's to be constructed of plastic. Plastic enclosures are produced using molds that are technically intricate and quite expensive. Because of this, manufacturers produce standard ranges of height, width and depth. For example, we produce enclosures (*Fig. 1*) from 2.0 by 2.0 by 1.6-inches in depth (52 mm by 50 mm by 40 mm) up to 40 by 32 by 11.8-inches (1,000 mm by 800 mm by 300 mm).

Figure 1: Standard and customized enclosures come in an array of types.

While modifications such as holes and cutouts can be made, the basic size dimensions cannot be altered. This forces the design engineer to deal with the packaging aspects of his or her project very early in the process.

Enclosure Materials

The environment will dictate the plastic material of choice since not all plastics work equally well in certain applications. For example, polycarbonate (PC) resists ultraviolet (UV) radiation while acrylnitrile-butadiene-styrene (ABS) does not. Therefore, ABS isn't a good choice for outdoor applications. And polyester (GRP) has better resistance to alkalis, but is more expensive than PC. However, a transparent cover of PC is more functional, with better environmental integrity, than a glued-in place window.

Simply put, when looking at chemical resistance, mechanical strength, weight, ease of modification, specific color match or a requirement for a transparent cover, there is no single plastic that does it all. Therefore the design engineer, with the help of the manufacturer's technical support staff, needs to carefully evaluate his or her application as well as the benefits and drawbacks of each option available before making the final selection (*see Figs. 2, 3 and 4*).

In the material that follows, we'll look at four of the more popular types of plastic enclosure materials: polycarbonate (PC), acrylnitrile-butadiene-styrene (ABS), fiberglass, glass fiber-reinforced polyester (GRP) and polystyrene (PS). (*For more details on the relative merits of each type, see Table 1*).

Polycarbonate

PC offers very high impact resistance, an opaque or high clarity transparent form, good resistance to chemical attack, a self-extinguishing flame rating, a wide operating temperature range, the ability to be easily machined with normal tools, a price tag that makes it cost effective for harsh environments and excellent insulating properties. One drawback is its lack of EMC shielding.

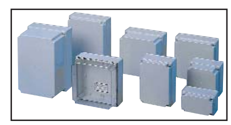

Figure 2: Shown are high impact resistant, glass filled polycarbonate enclosures, small to medium in size. They typically are used for electrical controls and instrumentation with either opaque or clear covers.

Acrylnitrile-butadiene-styrene

Among the benefits of ABS are the fact that it's light in weight and provides good resistance to chemical attacks. In addition, it looks a lot like PC, but is less expensive, can be easily colored using pigmentation and can be easily machined with normal tools.

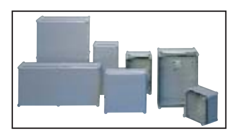

Figure 3: These medium and large size high impact resistant polycarbonate enclosures are used for electrical panels, internal wiring boxes, electrical control boxes, and instrument housings.

However, its impact resistance is lower than that of PC, as is its temperature range. In addition,

Figure 4: MNX polycarbonate or ABS plastic enclosures house and protect electronic components and equipment in harsh environments.

it provides no EMC shielding, is not suitable for outdoors since it degrades over time upon exposure to ultraviolet rays and it is not available in transparent form.

Fiberglass, Glass Fiber Reinforced Polyester

Glass fiber reinforced polyester offers a number of benefits, including excellent resistance to chemical attack, rigid construction, a wide operating temperature range, fire resistance and strong insulating properties.

But GRP also has some drawbacks. GRP is more expensive than PC and is unavailable in transparent form. It has less impact resistance, despite being heavier than other plastic enclosures. As well, GRP cannot be machined using standard tools, is susceptible to UV degradation, and does not provide EMC shielding.

Polystyrene

Polystyrene constructed enclosures typically are very low in cost, are easily colored using pigmentation, have good resistance to chemical attack, and can be easily machined with normal tools.

But polystyrene provides lower impact resistance than other plastics, lower operating temperature range than ABS and is not suitable for outdoor use because it degrades over time upon exposure to UV rays. It also provides no EMC shielding.

	PC	ABS	GRP	PS
Outdoor use	****	*	*****	*
Indoor use	*****	*****	*****	*****
Cost	***	*****	*	*****
Lightweight	*****	*****	***	*****
High rigidity	***	*	****	*
Impact resistance	*****	***	****	*
Chemical Resistance				
Salt water environments	*****	**	*****	**
Neutral salts	*****	****	*****	****
Acids, low concentrations	*****	****	*****	****
Acids, high concentrations	***	*	***	*
Alkalis, low concentrations	***	*****	****	*****
Alkalis, high concentrations	*	****	****	****
Petroleum	***	*	*****	*
Hydraulic oil	*****	*****	*****	*****
Alcohols	****	***	****	***
Solvents	*	*	*****	*
Cooling fluids	***	*****	*****	*****
	***** =	Excellent (highest customer benefit)		
	*	Poor (least customer benefit)		

Table1: Comparison of enclosure materials

Plastics, Now and in the Future

Engineered plastics continue to evolve. Continuous improvement in critical factors, like flammability, is the norm. New grades of polycarbonate have been developed to improve "low temperature" impact resistance, or to enhance endurance to long-term UV exposure, a critical factor for outdoor installations. For the wireless industry, unlike metal, plastics do not attenuate the RF signal. Unless you want it to. New plastics have been formulated to attenuate RF energy and use the enclosure to selectively focus the RF radiation. This permits the designer to shield one half the enclosure while permitting emission from the other half. The addition of new variations in engineered plastics means that innovative packaging solutions using plastic will continue to grow.

Don't Forget Enclosure Gaskets

The enclosure gasket seals the cover to the body and plays a critical role in establishing the unit's performance rating. The long-term reliability provided by the NEMA/IP rating depends upon the properties of the gasket material. Key performance factors of a gasket are its compression set and chemical resistance. Compression set is the amount of residual displacement after the compressing load has been removed. As is the case with the plastic used to make the enclosure, there is no single gasket material that's resistant to all chemicals. And keep in mind that the enclosure and gasket must withstand the same chemicals.

Standard enclosures come equipped with the optimum gasket material, as specified by the manufacturer. However, in some cases the gasket on a standard unit may be changed to alter the performance of the enclosure. When considering a change in gasket material, always consult with the factory to make sure your change won't have a negative impact on the overall design specifications.

Let's now look at some of the most frequently used gasket materials. Described below are the characteristics of polyurethane, thermo plastic elastomer, ethylene/propylene/diene, neoprene and silicone.

PUR (polyurethane)

PUR has become the gasket of choice in general-purpose applications. These gaskets are often called “molded in place” because they are produced by a two-part foam injection process that directly adheres the material to the enclosure cover with no gaps or joints. There is a mechanical gasket, groove or retainer that shapes and protects the gasket and assures a reliable NEMA / IP rating. (*Figure 5 shows a PUR gasket groove cross-section.*)

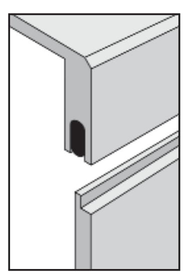

Figure 5: The groove profile of FIBOX enclosures is especially well suited for polyurethane injection foaming. This design, and a precision manufacturing process, ensures IP ratings up to IP 67.

TPE (thermo plastic elastomer)

TPE is a gasket material that is injection molded concurrently with the molding of the enclosure. Denoted as 2 component molding, this process produces a perfectly formed gasket without the process control variations of PUR technology. TPE molding technology, while very capital intensive, is now being introduced by innovative enclosure manufacturers, and promises to improve environmental ratings and long term performance, while eventually lowering the cost of production.

EPDM (ethylene/ propylene/diene)

EPDM gaskets have a very low permanent compression set, and can work in a temperature range of -50° to +120° C. In addition, ozone, oxygen and UV have little effect on these gaskets, which makes them suitable for outdoor applications. EPDM gaskets tolerate water, salt fluids, steam, alcohol, glycol, weak acids and alkalis, but are not resistant to many oils or hydrocarbon-based solvents.

Neoprene (chloroprene rubber)

Neoprene has good mechanical properties and offers a low permanent compression set. Its temperature range is -40° to +100° C, and it has excellent resistance to UV, ozone and oxygen. In addition, neoprene gaskets resist oils, fats, hydrocarbons and alcohols, but some of these agents may cause limited material swelling.

Silicone

Silicone gaskets have an exceptionally wide temperature range of -60° to +170° C. They are primarily used in extremely cold or hot environments. Silicone resists alcohols and ketones, but strong acids and strong alkalis have dissolving effects on the material.

Property	Unit	PUR	EPDM	Neoprene	Silicone
Temperature range	°C	-50 to +130	-50 to +120	-40 to +100	-60 to +170
	°F	-58 to +266	-58 to +248	-40 to +212	-76 to +338
Tensile strength	Mpa	0.4	13.0	8.4	9.4
Elongation at break	%	110	300	250	540
Hardness	Shore A	12	65	66	52
Density	g/cm3	0.33	1.12	1.6	1.15
Compression set	%	5	20	35	14

Table 2: Comparison of physical properties of gasket materials

Property	PUR	EPDM	Neoprene	Silicone
Chemical				
Neutral salts	****	****	****	****
Acids, low concentrations	***	****	***	***
Acids, high concentrations	*	***	*	*
Alkalis, low concentrations	***	****	****	***
Alkalis, high concentrations	*	****	***	*
Petroleums	*	*	***	*
Hydraulic oils	****	*	***	*
Alcohols	***	****	****	****
Cooling fluids	***	****	***	****
	****	= Excellent (highest customer benefit)		
	*	= Poor (least customer benefit)		

Table 3: Comparison of the chemical resistance of gasket materials

EMI-Compatible Gaskets

A plastic enclosure prepared for reducing electromagnetic interference (EMI) requires a gasket material that's electrically conductive. A wide variety of

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material choices exist. For example, in less demanding environments that require minimal electrical noise attenuation, a simple carbon or silver filled elastomer may be sufficient. However, in harsh industrial applications, a sophisticated gasket of silver plated, glass filled silicone elastomer, like ChoSeal 1350 (Chomerics), would be required.

With EMI shielding, a variety of interrelated factors come into play. Thus, to achieve the best solution, the design engineer will need to work closely with the factory.

Environmental Ratings

A number of organizations have defined enclosure performance criteria to help the engineer determine an enclosure's ability to withstand a specific environment. The dominant standard in the U.S. is NEMA (National Electrical Manufacturers Assoc.), and the one in Europe is IEC (International Electrotechnical Commission).

Presentations of these standards and the definitions of various ratings, such as NEMA 4 or IP 67, can be found in most manufacturers' catalogs. Generally, those companies supplying high performance, hostile environment plastic enclosures rate them as NEMA 4, 4X, 12, 13 and IEC 65, 66 and 67. Because these ratings cover most applications, the design engineer is often spared the detailed analysis of performance requirements (but not chemical resistance).

Always remember that all ratings apply to the finished standard enclosure as delivered by the manufacturer. Modification by the end user must be consistent with maintaining the rating required for the end product. Most manufacturers will readily offer design assistance to help you maintain the appropriate NEMA and IP ratings.

Modifications

Plastic enclosures are easier to modify than metal units. For smaller volumes, up to 1,000 units, most plastic enclosure manufacturers offer modification services using CNC machinery that can customize enclosures to the OEM's need. Lately, advances in CNC machining equipment and easier programming have reduced modification costs and greatly shortened lead times. Now CNC customization can be cost effective from low volumes up to 4,000 or 5,000 pieces annually.

For OEM's with larger requirements, say 5,000 to 15,000, it is often possible to customize the molding of a standard product to meet the OEM's specific needs. Provided the product mold is a sophisticated multiple slide mold, any enclosure side may be customized without requiring an entirely new mold. This can be a very cost-effective approach compared with creating a completely new custom mold. In essence, the OEM leases from the enclosure molder, a high volume, standard product mold that has been customized for his specific needs. This can be accomplished with minimal tooling costs.

Plastics have always offered the designer the ability to create a custom molded package, though at significant cost. Some enclosure manufacturers are lowering that cost by combining standard molded enclosure bases with custom molded covers. The resulting enclosure package closely approximates a custom enclosure and meets all the design objectives, but is based upon standard components and proven design techniques. The costs and risks of mold design will be greatly reduced. The part volume break even point will be lowered. Approvals, such as UL/CSA, if required, will almost certainly be easier to obtain and less costly. And most importantly, the time to market will be much faster.

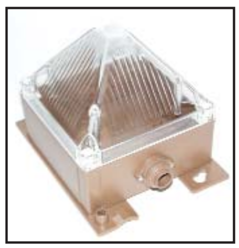

Figure 6: This unique enclosure consists of a custom molded prism cover mated to a standard, off-the-shelf, Fibox MNX base unit.

An example of this technique is shown in Figure 6. A custom cover, a clear pyramid shaped lens, was designed to interface with a standard Fibox MNX base. As the MNX base contains a concurrently molded TPE gasket, the new cover mold was simplified and less costly. Ingress ratings (IP 67) were assured, as the gasket interface remained the same as the standard product. The time to market was greatly reduced. The total quantity produced was 22,000.

Conclusion

Plastic enclosures are the product of choice for many hostile environment applications. Plastic is also becoming the product of choice for less demanding environments especially where custom requirements and aesthetics are critical factors. Optimum performance can best be obtained by ensuring the enclosure is applied correctly with regard to size, plastic material, gasket material, environmental rating and modification. Working closely with the manufacturer is key to success.

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Reprinted from the summer issue of Equipment Protection Magazine