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The Aluminum Case Advantage

Making the case for utmost protection

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Aluminum offers a superior blend of performance characteristics for reusable shipping containers. From low weight and cubic volume, to outstanding temperature performance, it's still difficult to surpass the performance offered by aluminum cases and containers. Aluminum is highly customizable, as well as being a highly recycled and recyclable material. Fabricated aluminum holds the added advantage that it custom sizes can be easily manufactured without time consuming and costly tooling.

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INTRODUCTION

A Packaging Engineer can predict a case's performance based on the structural materials used in its manufacture. In the last 75 years many new materials and processes have been introduced for the manufacture of reusable transportable shipping containers but none of them have surpassed aluminum for overall performance and rarely are any of these materials better than aluminum in any single container performance category. These new materials and processes have, instead provided a wealth of lower priced products that strive to match the overall performance of a well made aluminum case, but have yet to get there.

This white paper clearly acknowledges the need in the marketplace for lower priced products and lauds the significant advances that have been achieved in bringing traditional plastic/composite molding technologies and new materials to the case/container industry. The reader must acknowledge that lower price, in any industry, does not equal best value and seldom means improved performance and/or higher quality.

So this document will attempt to encourage purchasers of transit cases, shipping containers and transportable rack mount enclosures to make their selections based on "best value". An inexpensive carrying case may be very valuable to a salesperson transporting samples in the trunk of a car, but may have little value when being employed by a warfighter in combat.

Without question, a best value purchasing decision is far more difficult than simply choosing the lowest priced offer, but focuses on the needs of the end user and minimizes the overall costs of transporting delicate equipment. To facilitate a best value decision for the procurement of reusable shipping containers and/or rack mount enclosures, the remaining discussion will focus on key design and performance requirements and explain the compliance advantages of aluminum.

ROUGH HANDLING

Transportable shipping containers or rack mount enclosures exist primarily because handling cannot be controlled in most shipping environments. Products (delicate electronics in particular) require protection from impacts (drops) and vibration that usually can't be avoided.

For many years the U.S. Military endeavored to "harden" electronics so that it would continue to perform adequately in spite of rough handling that is inevitable during combat. The efforts to ruggedize the electronics yielded very expensive equipment and lengthened development times such that commercial off the shelf electronics was always technologically ahead of the equipment being provided to the warfighter.

The military ultimately discovered that a properly designed reusable case or enclosure with an engineered isolation system allowed them to utilize the latest equipment technology at a much lower cost than "hardening" electronics. Cases (even custom designs) can be developed far more rapidly than custom electronics and standard container products are typically available that can be fitted with custom isolation systems to ensure long term protection for equipment that is exposed to the harshest handling and/or environmental conditions.

The isolation system inside a transport or rack mount case is the primary attenuator of the energy that is otherwise transmitted (and potentially damaging) to the contents therein. In order for any case to provide the protection required by delicate equipment, it must form a relatively rigid structure to support this isolation system.

Isolation systems (foam cushioning or shock mounts) depend on a rigid exterior framework so that equipment movement (displacement) can be controlled effectively.

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The engineering formulae used to predict this movement assumes that the outer framework is *perfectly* rigid.

So why Aluminum?

A properly engineered aluminum case provides the rigid outer structure required to ensure optimum isolation system performance and content protection. Plastic cases (thermoformed and rotationally molded) absorb impacts (drops) by deforming. Plastic case materials are very flexible and can distort significantly before they crack or break.

The deformation (of these plastic cases) absorbs some of the shock that would otherwise be transmitted to the contents but it also dramatically reduces the amount of interior clearance during the impact. The reduction in clearance can result in a collision between the case and its contents that damages the contents while the case is unaffected.

An excellent example of the above phenomenon is the American Tourister advertisements of several years past that demonstrated the survival of their luggage when it was dropped from an airplane in flight. The case survived marvelously but you wouldn't have wanted your favorite stereo receiver inside.

Rigid plastic cases (injection molded and composite) avoid the deformation problem but are also far more apt to crack during impact especially when temperatures decrease below 0º F. Cracks offer a leak path for moisture and other contaminants and usually get worse when exposed to additional impact or vibration conditions.

The denting that occurs when an aluminum case is dropped also absorbs some of the impact energy that would otherwise be transmitted to the contents but denting typically

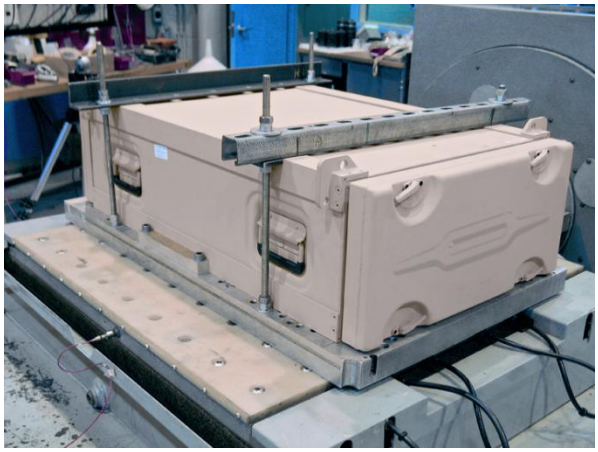
results in a very slight deformation of the case with respect to the allowable displacement and there is no significant distortion of the case as a whole. The allowable displacement between the case interior and the contents is not compromised and the isolation system can provide optimum protection for the contents.

The isolation system also requires a rigid exterior framework to minimize the potential damage/degradation that the contents may experience in a vibration environment. Rack mount isolation systems, when properly engineered, have a natural frequency higher than the most frequent transportation frequencies that the enclosure will experience.

Enclosure structures that are less rigid than aluminum cause the system natural frequency to decrease because the case sidewalls displace more (in response to the input vibrations) than the shock mounts. The lower container natural frequencies tend to be in the same range as frequencies driven by common motor cargo modes of transport and (when this occurs) the isolation system amplifies the input and places the contents at greater risk of damage.

Military requirements typically demand that isolation systems provide adequate protection for the contents over a frequency range of 5 to 200 hertz (Hz). Motor cargo transport over normal paved roads causes random inputs between 9 and 13 Hz.

If a case/enclosure is tested at the 5 to 200 frequency range (as recommended by MIL-STD-810), amplification of the input will occur, but the resulting displacement will decrease as the isolation system natural frequency increases. Cases that are dropped, however, will provide better protection for the contents if the isolation system natural frequency is reduced.



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Most case and enclosure isolation systems have to accommodate both drop and vibration environments. The only solution is a compromise that provides adequate attenuation of impact shocks at a system natural frequency that is higher than anticipated input frequencies. Such a solution is possible only when the exterior container is rigid enough to ensure the isolation system performs as intended.

A properly engineered aluminum case provides the rigidity necessary for effective isolation system performance and predictability without compromising other important performance demands.

WEIGHT

Weight should be a consideration in any Transport or Rack Mount Case procurement evaluation because every additional ounce increases the cost to the end user. The most common end user cost affected by increased weight is the freight or shipping charge.

Freight charges are almost always adjusted with regard to weight as well as volume, but even if the freight rate is based on volume only, increased weight means increased cost when special handling (fork lift trucks, etc.) is necessary or large quantities compromise vehicle load limits. Increased weight almost always results in increased time and that's a cost that's difficult to quantify and impossible to recover.

Freight charges are seldom the highest cost resulting from increased weight. To a warfighter, it's usually mission success. If a critical piece of equipment cannot be employed rapidly enough because it is too heavy to move effectively or requires additional personnel (that aren't immediately available), a mission could be lost and lives may be placed in greater jeopardy.

The warfighter example represents a unique requirement for light weight cases but material handlers risk injury daily handling freight that is heavier than necessary. The

cost of personnel safety includes medical expenses, insurance, downtime and many hidden organizational costs. The lighter the product, the less risk there will be for an injury and fewer injuries reduce insurance costs and downtime losses.

So why Aluminum?

Because it has a tremendous strength to weight ratio and an extremely rugged case can be manufactured with relatively thin walls. In spite of the multitude of material advances in the last 50 years, aluminum cases are still lighter than any other comparable competitive product at the same or lower price.

Most of the plastic and composite materials used for cases today exhibit a lower density (lighter material weight) than aluminum but they require wall thicknesses much greater than aluminum to provide the strength and/or rigidity required to operate successfully in transport/handling environments. The added wall thickness overshadows the lower density and the resulting plastic or composite case is heavier than the aluminum case that meets the same performance criteria.

Carbon fiber materials can be used to provide cases that are lighter than aluminum counterparts, but these cases are typically twice the price of an aluminum case and may be three times the price. The purchaser must be cautious as well because some carbon fiber products contain a portion of the carbon fiber material such that the overall weight of the resulting case may still be higher than a similar aluminum case.

There's a reason that airplanes are made primarily out of aluminum and the same basic principles apply to transport cases and rack mount enclosures. Weight is not always the most critical factor in case selection but it should always receive consideration and when weight is critical to mission accomplishment or personnel safety, aluminum cases are still the best value.

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TEMPERATURE EXTREMES

A product transported across the U.S. in a standard eighteen wheeler that doesn't have a temperature controlled trailer may experience temperatures as high as 180º F for several hours. Worldwide temperature extremes can exceed 220º F under similar conditions.

In the winter these same products may sit overnight at temperatures well below zero and be handled in equally low temperatures when delivered in the Northern U.S. or Alaska. Again, worldwide conditions may be significantly more severe.

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Temperature extremes will ultimately affect all materials. Extreme heat can lead to deformation and eventually melting. Low temperatures may cause stress cracking or embrittlement. All of these conditions degrade the performance of a transport case or rack mount enclosure.

So why Aluminum?

Because aluminum cases will not be affected by any of the above conditions until the temperature extremes are well in excess of those that will be experienced anywhere on earth. Unreinforced plastic cases will begin deforming when the temperature gets to 122º F and will permanently deform if the temperature exceeds 180º F.

Aluminum cases will not experience this type of deformation unless temperatures exceed 500º F or go to cryogenic lows. Aluminum also has a very low rate of thermal expansion which means the covers will always go back on the case without forcing and tolerances can be held far more tightly on features and hardware locations.

The most overlooked advantage of aluminum that results from the low rate of thermal expansion is pressure control in sealed cases. The thermal expansion of plastic cases when used in sealed applications will lead to deformation (usually temporary but sometimes permanent) caused by the expansion of the internal air mass and the resulting increase in internal pressure. Plastic case manufacturers counter this pressure increase by employing pressure equalization valves that have relatively low (.25 to .50 psi) reseal pressures.

The low pressure valves minimize the deformation but they actuate more frequently than higher pressure valves. For example, a .5 psi valve may actuate twice daily under normal daytime/nighttime temperature excursions whereas a valve with a 1.0 psi reseal pressure will only actuate 6 to 10 times per year when exposed to the same conditions.

This number of actuations is important because each time the case “inhales”, the moisture content of the interior air mass increases. If the air mass becomes too moist, condensation will occur and the equipment inside will be coated with moisture. The side wall strength of aluminum cases is adequate for the use of the higher pressure valve.

Injection molded plastic cases minimize the above problem by adding a blowing agent to the plastic during the molding process. Blowing agents increase the rigidity of the plastic material so that it doesn’t deform as severely. The increased rigidity means decreased impact resistance so one performance goal is compromised for another. Aluminum cases don’t have to make this compromise.

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WATER INTRUSION

Most transportable case and rack mount enclosure applications include contents that do not perform well if exposed to moisture and cases for such equipment are preferred if they minimize the amount of water and/or moisture that is allowed to ingress the case when it is exposed to rainfall, sitting in a puddle, etc. Rack mount enclosures seldom have the luxury of allowing moisture ingress because the electronics contained therein is difficult to protect otherwise.

Extreme applications may require the need for minimizing water ingress in the event the case is submerged. Because sealed cases require a pressure relief valve, the valve must be selected to ensure resistance to the ingress of water.

So why Aluminum?

For many of the same reasons that have already been discussed. The thermal stability of the aluminum case ensures precise fitting covers regardless of temperature. The rigidity of the aluminum case structure resists sidewall deformations that can otherwise lead to gaps in the closure.

Aluminum cases can employ precisely mounted hardware that is essential to ensuring uniform compression on the closure gasket seal. Case seams can be welded such that material strength is improved and potential leak paths are eliminated.

Closure mating features can be formed to tight tolerances that are not subject to fickle molding parameters. And aluminum is relatively non porous compared to composites and most plastic case materials.

CORROSION RESISTANCE

When most of think of corrosion we think of rust, but there are many forms of chemical corrosion caused by acid spills, reagent contact, etc. All materials are subject to some form of corrosion but most cases will never experience the harsh or exotic chemical compounds associated with acids and harsh cleaning agents.

All cases are typically exposed to moisture. So why Aluminum?

Aluminum cases don’t have a significant advantage over most plastic cases in this regard but neither do they have a disadvantage. Most materials used in cases today are corrosion resistant in normal shipping and handling environments.

EMI EFFECTIVITY

EMI effectively can be addressed in very complex terms but for most applications EMI shielding requires a Faraday cage around the equipment requiring protection. Any gap in the cage will allow some leakage and if the case contents are susceptible to that frequency range or if sensitive data can be compromised by the emission of those frequencies, the EMI effectively is inadequate.

So why Aluminum?

Aluminum cases can be fabricated with welded or formed seams to eliminate most radiation leakage with little additional cost in manufacturing processes or material content. Plastic and composite materials require some type of conductive supplement to the nonconductive basic materials and these supplements significantly increase material/labor costs. These supplemental materials are difficult to employ in the case manufacture and often easily damaged when the case experiences rough handling environments or temperature extremes.

MANUFACTURABILITY AND CUSTOMIZATION

Today's sophisticated electronics and complex systems usually demand a case designed to meet specific requirements and/or operating conditions. Such a case usually begins with a standard or existing configuration and is modified to meet a customer's precise requirements.

Case designs can't be finalized until the content configurations are well defined. In other words, the case becomes the last step in the program or product development. This becomes a common case manufacturing challenge because the customer is now ready to ship product and needs the cases immediately.

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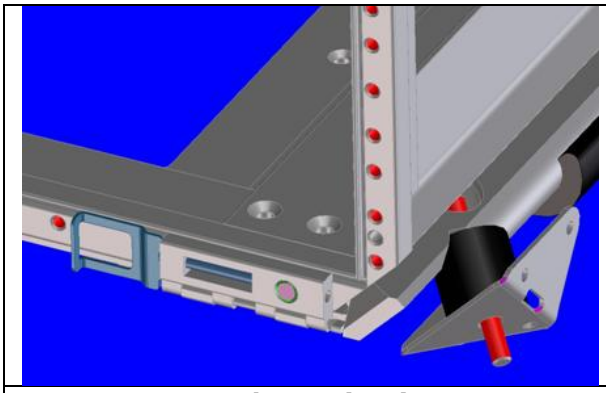
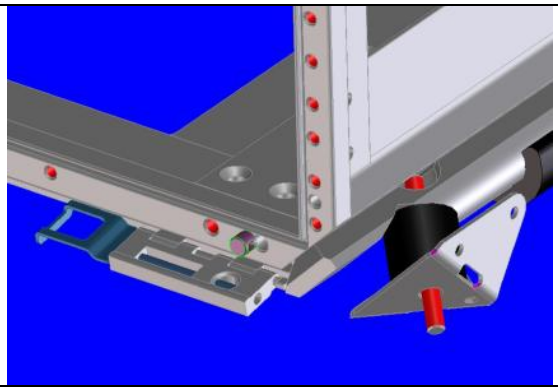
So why Aluminum?

Zarges aluminum cases can be custom designed and manufactured without tooling time because they are fabricated from sheet metal stock and standard profiles that can be incorporated in a variety of ways. Unique sizes are not limited by mold availability and aluminum can be “worked” in a variety of ways to produce special features such as cutouts, interior panels, hardware protectors and countless others.

Zarges also operates the most sophisticated ISO 9000/9001 qualified manufacturing capability in the case industry which includes a wealth of robotic equipment, highly trained metal workers, and a reliable, consistent engineering and management team. These resources collaborate effortlessly so that Zarges customers receive on time shipments whether they are buying one case or 5000 cases.

Removable Rackmount

A recent Zarges innovation is a 19” EIA/CEA rackmount case affixed by (4) quick release pins. These are the strongest, easiest quick release mechanisms on the market.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Heating and Cooling

Zarges aluminum cases are well suited for these types of applications. Aluminum itself is an excellent conductor of heat and works well to radiate internal heat loads.

Zarges has worked with all the major methods of heating and cooling, and can offer custom tailored solutions.

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Summary

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