EASTMAN

Eastman Tritan™ copolyester

Secondary operations guide

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Eastman Tritan™ copolyester balances the properties of easy processing, clarity, toughness and heat and chemical resistance, creating value across a broad spectrum of markets, including housewares, small appliances, infant care and medical. As a result, Tritan is often used in applications requiring joining and/or assembling multiple components, as well as decorating processes used to enhance the appearance or even functionality of the article.

In designing parts for assembly and/or decoration, it is vital that informed decisions be made regarding joining or decorating technique to ensure that the final article maintains the inherent properties of Eastman Tritan™ copolyester. The design of parts and assemblies which maintain excellent appearance and a high level of functionality requires consideration of a number of factors. The designer must have:

- Knowledge of the attributes of Tritan
- Fundamental knowledge of good design practices used for joining thermoplastics
- A thorough understanding of the intended use of the assembled article, including the application environment, chemical exposure and mechanical load which the assembly will encounter

The intricacies of part design for good assembly performance highlight the need for a working relationship between part designer, joining technology/equipment supplier and Eastman technical representatives.

The guidelines in this publication are rules of thumb for part assembly and decoration. There may be exceptions to these guidelines or times when recommendations may conflict with the fitness-for-use criteria of the final part. In these cases, consult your Eastman technical representative for assistance. Prototyping and part testing are always required prior to transitioning an application to full commercial production.

Joining and assembly

Parts made from Eastman Tritan™ copolyester can be assembled using a wide variety of joining techniques. The choice of assembly method is closely linked with the end-user requirements of the application. Eastman offers a range of services including application development, 3-D modeling and technical service to aid in choosing the appropriate processes for each application.

Adhesives, ultrasonic welding and laser welding have been shown to be effective means for joining components produced from Eastman Tritan™ copolyester. In addition, snap-fits and mechanical fasteners can be used to assemble articles produced from Tritan.

Methods for joining parts made of Eastman Tritan™ copolyester

Chemical	Adhesive bonding
Mechanical	Screws Inserts Snap-fit joints
Thermal	Ultrasonic welding Laser welding Spin molding Hot plate welding

Adhesive systems

A variety of adhesives are available for joining plastic materials. As a result, it is difficult to make general observations. Unlike solvents, which evaporate, an adhesive layer remains a functional part of the finished assembly. Hence, the performance and appearance of the finished part may depend primarily on the characteristics of the adhesive layer. Several characteristics to consider when selecting an adhesive are:

- Chemical compatibility with the parts being joined
- Aesthetics of the finished joint
- Expansion/contraction with temperature changes
- Brittleness, rigidity, flexibility
- Durability/service life
- Adhesive strength (adhesion to the plastic)
- Cohesive strength (resistance to internal tearing)
- End-use requirements

Note: If expansion and contraction are a major concern, consider the use of mechanical fastening.

Adhesive bonding procedure

The surfaces of Eastman Tritan™ copolyester parts which are to be joined using adhesive systems must fit well without forcing and have no visible gaps. The surfaces to be bonded should be smooth but not polished. Sand the surfaces to be joined with a 120-grit or finer paper. Diamond-wheel polishers, jointers/planers or other mechanical devices can produce excellent results. However, soft-polishing wheels or flame polishing are not recommended, as these can round the edges causing gaps and improper fit.

The following are a selected number of commercial adhesive systems which have been shown to perform well in bonding Eastman Tritan™ copolyester to itself:

Weld-On® 55
Lord® adhesives 7542 A/B
Flex Welder™ 14345
Lord® adhesives 403/19
Lord® adhesives 406/19
Lord® adhesives 406/17
Plastic Welder® II 14340

Evaluation of adhesive performance was done according to ASTM D1002.

The adhesive systems listed above do not represent a comprehensive set but merely those which have been evaluated in internal testing and are recommended for use with Eastman Tritan™ copolyester. For best performance, please follow the guidelines for use provided by the adhesive manufacturers. A careful evaluation of the part application should be done prior to selecting an adhesive system to ensure the adhesive provides both acceptable performance (bond appearance and strength) and meets all necessary regulatory requirements.

Some adhesives with a volatile component may shrink while curing. To compensate for shrinkage, cut the joint on an angle, thereby providing space for the joint to be slightly overfilled. Consult your adhesive supplier literature for specific information on shrinkage.

For assistance with bonding Eastman Tritan™ copolyester to other materials or additional information on adhesive bonding of Tritan, contact your Eastman technical representative.

Ultrasonic welding

Ultrasonic welding is a common method for joining plastics without the use of adhesives, solvents or mechanical fasteners. Ultrasonic welding equipment operates on the principle of converting electrical energy to mechanical vibratory energy. Vibratory energy is transferred to plastic parts through a specially designed horn. In addition to energy transfer, the horn serves to apply pressure to the parts being welded which aids alignment during welding. High-frequency vibration generated by the welding machine causes frictional heat which softens the plastic to create a bond at the contact points between plastic parts. After heated material flows into the joint area, the welding horn maintains some applied pressure to prevent movement during solidification.

Compared to other joining methods, ultrasonic welding offers several advantages, including:

- Environmentally safe — no chemicals used
- Aesthetically pleasing joints
- Excellent product uniformity
- Rapid bonding and high productivity
- Computer-controlled process — suitable for statistical process control

Optimization of an ultrasonic welding process requires consideration of three primary factors: material properties, part and joint design, and fitness-for-use requirements of the application.

- Material properties impact the transfer of vibratory energy from the horn interface to the joint. As a result, a change in material should lead to a reevaluation of design and process.
- Part and joint designs are vital in determining the performance of a material in the final assembled part. As with material properties, the part design influences how effectively energy is transferred to the weld area. Joint designs are instrumental in determining weld quality as they serve to focus applied energy, supply appropriate melt volume to the joint and provide part alignment during the welding process.
- Fitness-for-use requirements must be considered as these factors influence the type of joint chosen for the part. Factors such as applied load, need for hermetic seal, joint appearance and the tolerance for flash factor into the choice of joint design.

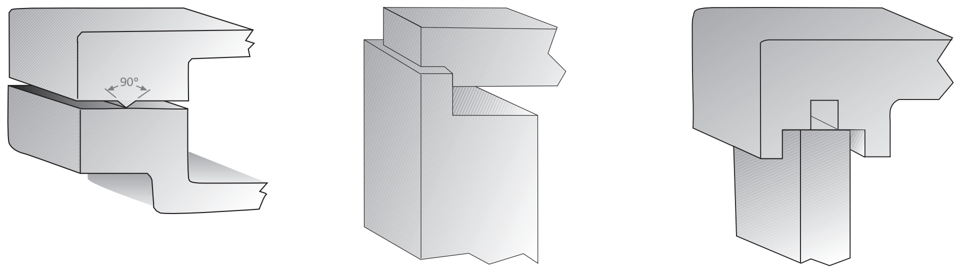
Strong bonds can be achieved using ultrasonic welding with most amorphous plastics, given appropriate welding parameters. Parameters that significantly affect weld strength and appearance include vibration frequency and amplitude, applied pressure, load, time and joint design. Additional considerations should be given to the mode of operation of the welding equipment as this can impact weld integrity. Control methods include weld time, collapse distance and weld energy.

Following are general guidelines on joint designs that have been shown to perform well with Eastman Tritan™ copolyester. Ultrasonic welding is a complex process involving a number of factors with each application bringing a unique set of challenges. As such, it is vital that part designers and engineers contact their Eastman technical representative to discuss details and specifics of each application.

Joint designs

Eastman Tritan™ copolyester can be ultrasonically welded using both energy director and shear-type joint designs. A sampling of common joint designs is shown in Figure 1.

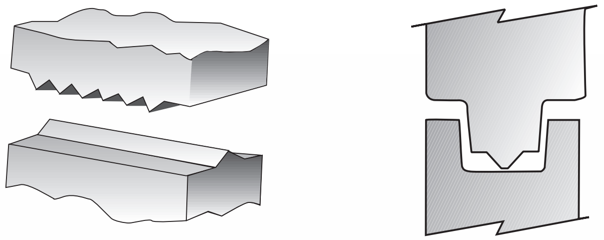
Figure 1 Common ultrasonic weld joint designs including energy director and shear-type joints



Energy director designs

Energy directors serve to focus the applied vibratory energy to speed softening and melting at the joint interface. Rapid softening and welding speed the welding operation and minimize horn contact time, thereby reducing the potential for scuffing of the part surface. The basic energy director design is shown in Figure 1. The energy director is typically a raised triangular feature molded into one surface of the joint.

Figure 2 Improved energy director joint designs



Improvements on the basic energy director joint design are highlighted in Figure 2 . The use of crisscross designs provides additional material to flow into the joint for stronger bonds and hermetic seals. The use of tongue-and-groove designs ensures joint alignment, prevents flash and promotes a hermetic seal.

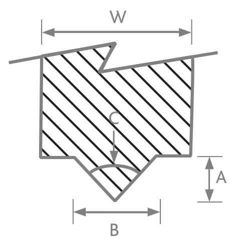
In addition to the joint alterations highlighted in Figure 2, the incorporation of surface texture on the joint face opposite the energy director has been found to improve frictional characteristics and melt control. Pattern depths for this texture typically range from 0.003" to 0.006" (0.075 to 0.15 mm).

Recommendations on the geometry of energy directors for use with Eastman Tritan™ copolyester are shown in Figure 3. Note that these recommendations are in agreement with typical energy director designs found for common amorphous thermoplastics, excluding polycarbonate and polymethylmethacrylate. The primary features of the design are a 90° apex angle (noted as C in the figure) and height and width governed by part wall thickness (W).

Shear-type joint designs

In contrast to energy director joint designs, shear joints can offer improved toughness and durability, as the weld area can be varied readily through changes to depth. Shear-type joint designs provide an interference fit between parts to be joined. Interference is typically in the range of 0.008" – 0.012" (0.2 mm – 0.3 mm). Shear joints can be either single-sided or double-sided, as highlighted in Figure 1. As the vibrating welder horn presses the parts together, the interfering material softens and creates a bond at the interface. Some general recommendations on shear joint design are shown in Figure 4.

Figure 3 **Energy director geometry and size recommendations**



W - wall thickness
A - energy director height
B - energy director width
C - included angle

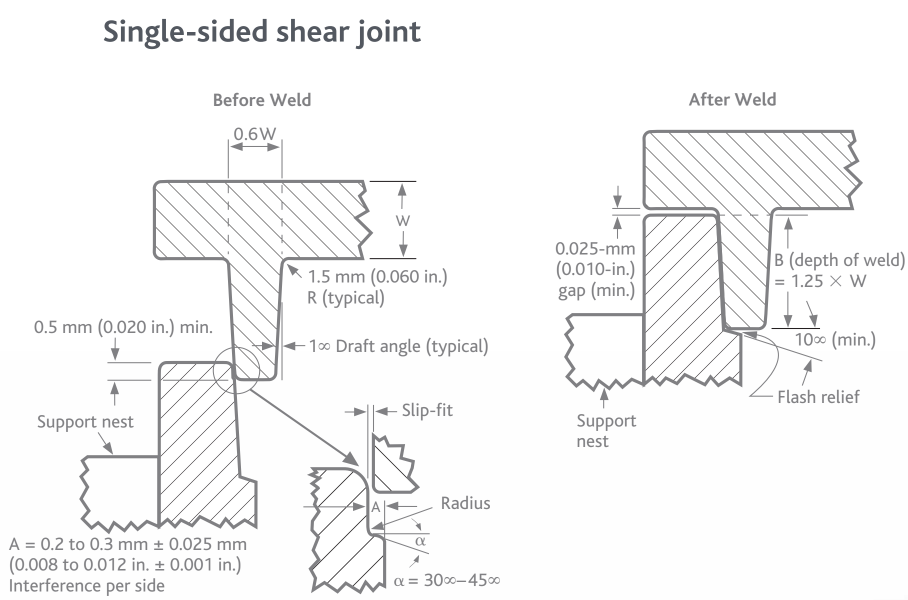
Recommendations on energy director size:

A = W/8

B = W/4

C = 90°

Figure 4 **Shear-type joint design recommendations**



Ultrasonic welding of Eastman Tritan™ copolyester can be successfully accomplished with proper joint design and the use of proper welding parameters. Part designers must carefully select the joint design that provides optimum performance and utility to satisfy the end-use requirements of the functional part. Designers should consult their welding equipment supplier or Eastman technical representative and conduct rigorous real-life, end-use testing during product development. Following is a list of equipment suppliers:

Branson Ultrasonics Corporation
41 Eagle Road
Danbury, CT 06813-1961 U.S.A.
Tel: (1)203-796-0400

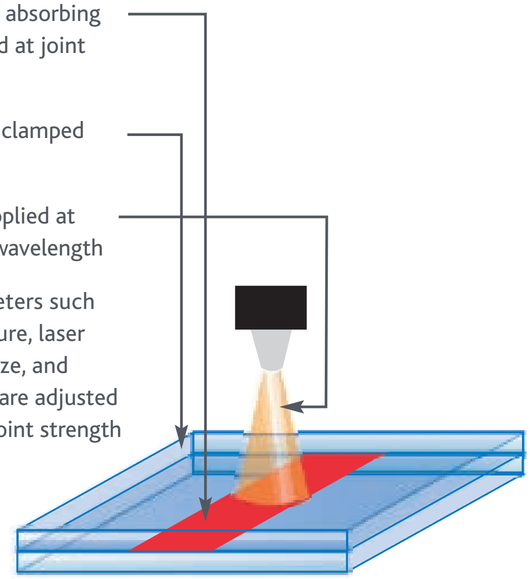
Dukane Intelligent Assembly Solutions
2900 Dukane Drive
St. Charles, IL 60174 U.S.A.
Tel: (1)630-797-4900

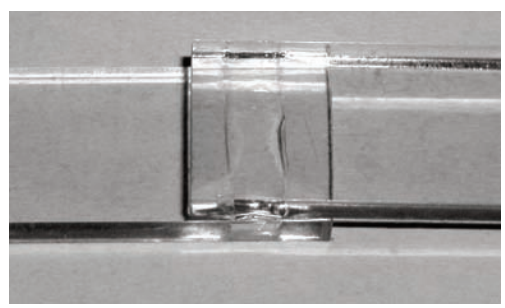
Hermann Ultrasonics Incorporated
1261 Hardt Circle
Bartlett, IL 60103 U.S.A.
Tel: (1)630-626-1626

Laser welding

Through-transmission laser welding utilizes near-infrared laser energy (wavelength of 800 – 1100 nm) to excite laser-absorbing additives which generate heat at a joint surface. Softening or melting of the thermoplastic in combination with externally applied clamping force causes the two mating surfaces to weld. Developments such as the Clearweld® welding process by Gentex Corporation have expanded the application space for laser welding to include transparent assemblies. In this process a near-infrared absorbing Clearweld® fluid is applied to the joint interface. Alternatively, a Clearweld® additive is incorporated into the bottom substrate of the assembly. On application of laser energy, the Clearweld® material absorbs energy, resulting in heat and subsequent welding.

Figure 5 Schematic of the laser welding process and example of joint attainable using Clearweld® technology





Desirable characteristics of the laser welding process:

- Excellent joint strength with Eastman Tritan™ copolyester
- Excellent welded joint aesthetics
- No creation of flash or particulates during welding
- Very short weld cycle time
- No cure time requirement

Laser welding of Eastman Tritan™ copolyester was evaluated using a simple lap shear joint which was tested under tensile load. Welds formed have excellent aesthetics maintaining clarity and near colorless appearance. Tensile testing showed all weld failures to be substrate type, indicating excellent weld strength.

For additional information on the use of laser welding and the Clearweld® technology with Eastman Tritan™ copolyester, please contact your Eastman technical representative.

Decorating

The use of decorating techniques allows the part designer to add functionality and aesthetically pleasing element to parts produced from Eastman Tritan™ copolyester. Tritan is amenable to a number of decorating techniques, including (but not limited to) painting, overmolding, printing and the use of decals and labels.

Painting

Painting may sometimes be required to add a special decorative effect or to improve the functionality of the plastic surface. Some typical reasons to choose paint include:

- Improved chemical, abrasion or weathering resistance
- Color matching with adjacent parts or components
- Wood grain, luminescent or metal flake appearance
- Electrical conductivity
- Extra high-gloss or matte finish
- Textured appearance where molded-in texture is not possible

There are two basic types of commonly used paints. One is the lacquer type which dries strictly through solvent evaporation. The second is a curing-type paint or enamel which usually requires a bake to obtain its performance properties. Both types (lacquers and enamels) have certain advantages and disadvantages. Follow the manufacturer's guidelines for optimum results.

Following is a list of selected paint suppliers:

Red Spot Paint & Varnish Company	www.redspot.com
Sherwin Williams Company	www.sherwin-williams.com
Nippon Paint Company	www.nbcoatings.com
Eastern Chem-Lac Company	www.easternchemlac.com

Overmolding

The use of overmolded soft-touch materials is commonly employed to add both functional and decorative elements to articles produced from rigid thermoplastics. Eastman Tritan™ copolyester has been shown to have excellent adhesion with commercially available TPE grades. In selecting the TPE grade for use, it is vital to work with either the TPE supplier or Eastman to choose a grade which is formulated for use with a copolyester substrate.

Part design considerations:

- Optimize part thickness and TPE thickness for adhesion and dimensional stability. TPE thickness in excess of the Eastman Tritan™ copolyester part thickness could result in warpage on removal from the mold. Typical rule of thumb recommends substrate thickness twice that of TPE.
- Mechanical interlocks can be incorporated to improve TPE adhesion and promote part durability. Mechanical interlocks become particularly important with thin TPE layers or very demanding fitness-for-use requirements.
- For designs incorporating soft-touch features on multiple surfaces, flow-through designs should be used to improve adhesion and durability.
- To minimize the potential for peeling or delamination, the edge of the TPE should be flush with or below the level of the non-overmolded section of the rigid substrate.

For further part design and specific processing information, consult appropriate literature available from your TPE supplier.

It is important to consider the end-use environment of the overmolded article when selecting the appropriate TPE grade. In each case, the particular fitness-for-use criteria should be taken into consideration.

Printing

Printing is a commonly employed method for application of designs, characters or other markings on parts produced from Eastman Tritan™ copolyester. As with traditional copolyesters, graphics can be easily printed onto parts produced from Tritan. Unlike materials which require a secondary process, such as flame or corona treatment to enhance ink adhesion, Tritan has been shown to print well in the as-molded state. Printing on Tritan has been accomplished under a number of printing methods. The use of appropriate ink systems has been shown to produce parts having high-quality graphics with excellent durability in life-cycle testing.

Eastman has engaged the following ink suppliers in evaluating the performance of Eastman Tritan™ copolyester in printing operations:

Nazdar
8501 Hedge Lane Terrace
Shawnee, KS 66227-3290 U.S.A.
Tel: (1)913-422-1888

Sun Chemical
35 Waterview Boulevard
Parsippany, NJ 07054-1285 U.S.A.
Tel: (1)973-404-6000

For assistance with painting Eastman Tritan™ copolyester, contact you Eastman technical representative.

Labels and decals

Self adhesive labels and decals offer a simple method for applying graphics such as logos, model identification and decorative graphics. Available labels and decals offer a wide variety of colors and shapes. Labels and decals can also be classified as either temporary (designed to be easily removed at some point in the product life) or permanent (designed to remain in place and offer a durable, aesthetically pleasing appearance over the entire part life).

Important criteria to consider when selecting a label or decal:

- Is the decoration temporary or permanent?
- Should the label be clear, semi-transparent or opaque?

Both of the above criteria play a critical role in selecting the label system to be used for a given application. It is important to work with an Eastman technical representative or your label supplier to select the appropriate label system for a given application.

Following is a general recommendation for types of labels to be used with Eastman Tritan™ copolyester:

- For temporary or removable labels, use systems based on PET, polystyrene or biaxially-oriented polypropylene (BOPP) film backing

Following is a general comment regarding caution about the types of labels and decals which should be avoided with Eastman Tritan™ copolyester:

- Temporary or removable labels produced from plasticized PVC substrates should be avoided, as problems with label removal may result.

Let Eastman help

Eastman Tritan™ copolyester offers a unique balance of easy processing, clarity, toughness, and heat and chemical resistance, resulting in use of the material across a broad spectrum of applications. In many of these applications, Tritan parts are assembled into larger components and decorated for functional or aesthetic reasons or both. Therefore, it is vital that Tritan performs well in a range of joining and decorating processes. Highlighted herein is a range of secondary processes that can be used to achieve highly functional and aesthetically pleasing parts, creating value at both processor and brand-owner levels. As there are often intricacies in the operations described above, designers and engineers are encouraged to consult their vendor and Eastman technical representative for support.

For more information about using Eastman Tritan™ copolyester in a secondary process, contact your Eastman technical representative today.

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