



*form and function™*

## ***CFRT® General Part Design Guidelines***

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## General Part Design Recommendations

This document has been written to assist our customers in the design of parts made from CFRT® (Continuous Fiber Reinforced Thermoplastic) composite materials using a compression molding process. This is an evolving / living document and is meant as a starting point to the eventual widespread use of CFRT® in compression molding. The manufacture of CFRT parts with compound details as described in this document is a breakthrough in the field of composites which has only just begun. This first edition identifies conservative design constraints that will secure successful first run production parts. Please contact us on any comments that you may have on how we can improve this document. Notice that mold design will not be covered herein and material properties can be supplied as needed in separate documentation.

### 1. Overall Structure

A four (4) sided structure with 4 sidewalls would be the most stable design. This concept allows for the best overall strength and dimensional stability. The current proto-type structure (pictured below) is not ideal and is sensitive to molding parameters and materials.



## 2. Wall Thickness

### 2.1. Minimum Thickness

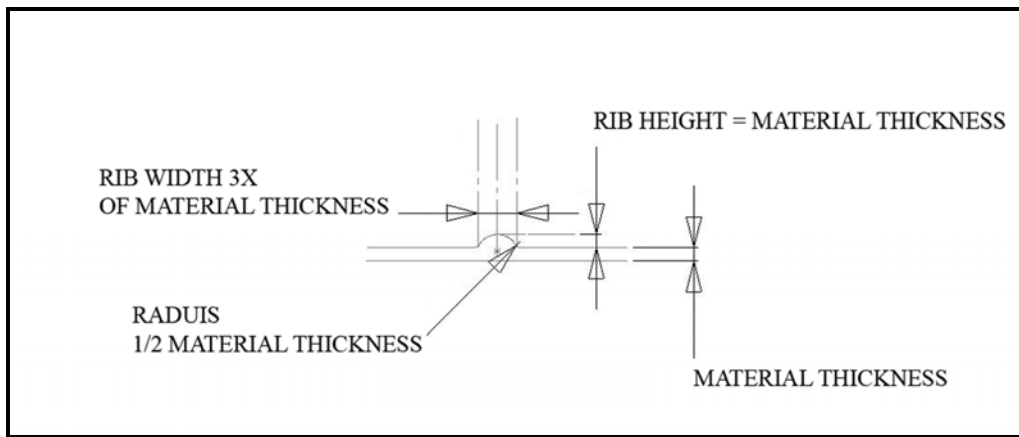
The part thickness is governed by a balanced laminate structure requirement. Currently the thinnest balanced laminate possible is approximately .032" (0.8mm) thick. This minimum thickness is dependent on the CFRT material. The section stiffness should also be considered when reviewing thin wall sections.

### 2.2. Thickness Transitions

The transition of part thicknesses for CFRT® is not limited to thick-to-thin transitions as in injection molding processes. Compression molded CFRT is inherently a short flow process. The kits of material are built so that material is placed where it is needed before molding. This allows for thick-to-thin and thin-to-thick transitions any where in the part. However, these transitions should be gentle and as smooth as possible.

## 3. Ribs

Ribs are a specialized case of part thickness transitions used for geometric stiffening of a part. The following is recommended for ribs in CFRT® parts.



## 4. Bosses

Bosses can be molded in CFRT parts. The base thickness of a boss should be at least 0.9mm thick. At least a 3 degree draft on the walls of the boss is best.

## 5. Gussets

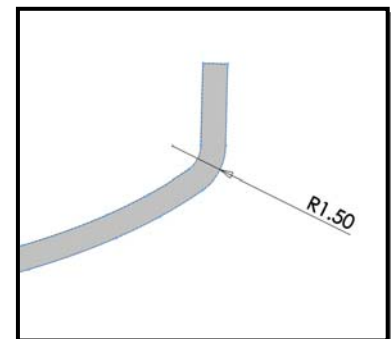
Gussets are rib like features used to add support structures such as side walls. They are also used as alignment mechanisms. Gussets should be a minimum of 0.9mm thick at the bottom with a 1 to 3 degree draft on all walls. Vertical details can be thicker than the horizontal wall. (Sinks are eliminated or minimized by the designed in localized build up of materials. Common plastic part design rules *do not* apply when considering gussets.)

## 6. Sharp Corners

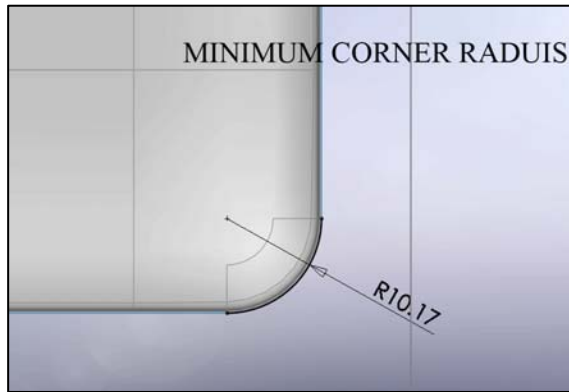
Sharp Corners as in plastic part design are not recommended and should be evaluated on a part by part basis.

## 7. Minimum Radii

It is difficult to determine the absolute minimum radius to be used in a new CFRT part design since we have had minimal molding experience. Our conservative approach is to limit corner and fillet radii to what has been successful to date. A 0.9 to 1.5mm minimum radius in the cross-section of the shape has been successful so far.



From the Plan view of a part, a minimum radius of approximately 10 mm will work.



Corners that are enclosed/trapped or isolated will not form properly and should not be used.

**Avoid This Type of Corner**

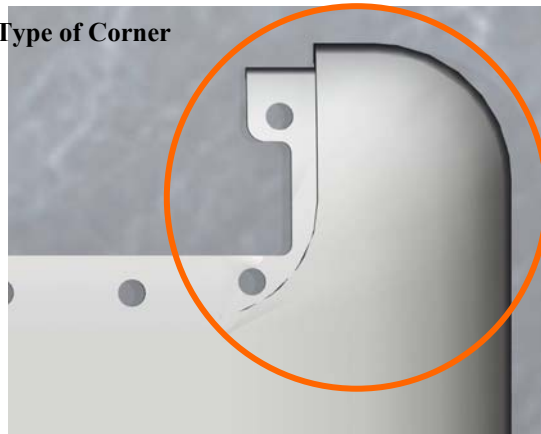


Figure 1 Example of an enclosed/trapped or isolated corner

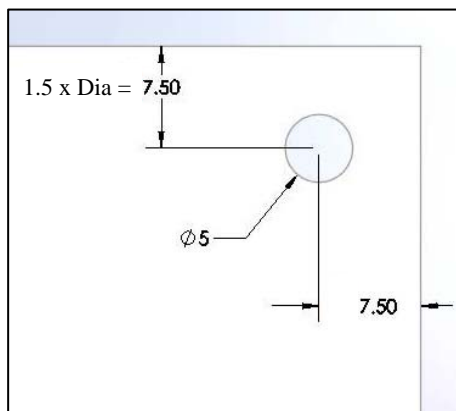
### 8. Draft

Draft angles on features that are parallel to the direction of release should be  $1^\circ$  per side and  $3^\circ$  for easier release. When using texture on a vertical wall use the standard one degree of draft plus one additional degree of draft for every .001" (0.025mm) of texture depth as a rule of thumb.

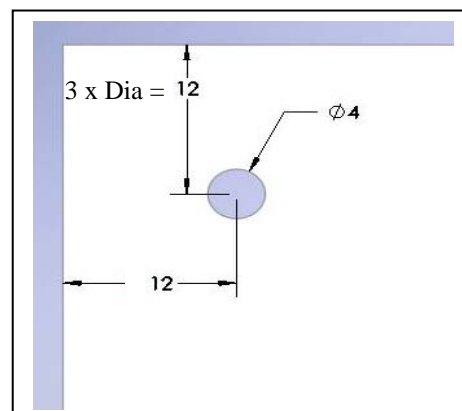
### 9. Holes and Cores

Holes, and the cores to make holes, during the molding process are not recommended for CFRT parts. Holes may be designed for use in CFRT parts but they would be drilled after the molding process. For non-structural holes an edge distance of 1.5 times the diameter is recommended and for a structural hole 3 times the diameter to the edge is recommended.

Non-structural hole placement

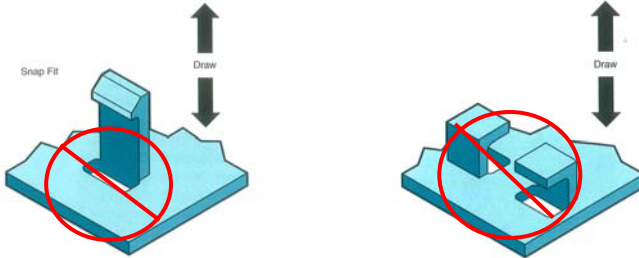


Structural hole placement



### 10. Undercuts

There should be no through-hole undercut designs used in CFRT part design. Long thin details should also not be used. Core side lifters are OK to be used for undercuts.



### 11. Louvers and Vents

Through-hole louvers and vents can not be molded into a CFRT part. The recess for a louver or vent can be made but a secondary milling operation will be needed to make the opening go through the part. Long thin core sections should also be avoided here as well.

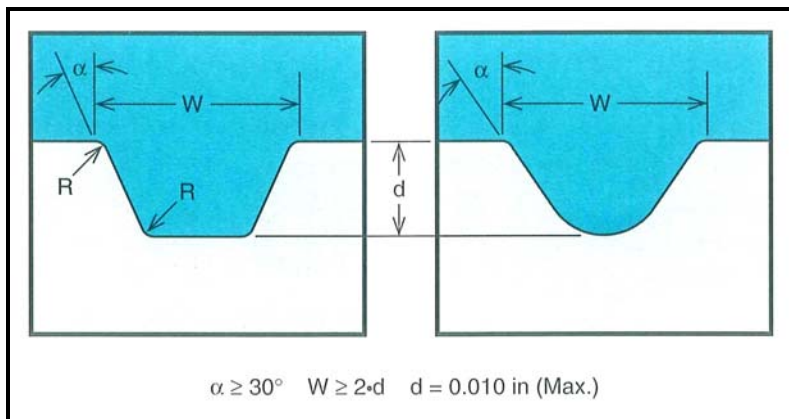


### 12. Threads

At this time in-mold threads are not recommended.

### 13. Lettering

The CFRT molding process adapts nicely to molded-in lettering. The recommendation for shape and depth are shown below in cross-section.





















### 14. Tolerances




Tolerances for CFRT parts should follow those of injection molded plastics. In general CFRT parts should be very dimensionally stable. It is recommended that geometric dimensioning and tolerancing (GD&T) be used in accordance with ASME Y14.5M-1994.

### 15. Decorating

Different decorating techniques have been tried at an R&D level but not proven in production. The following chart is an indication of what TC3 feels is compatible with a few of our Carbon Fiber reinforced CFRT materials.















Decorating Technique	PET- Carbon CFRT®	PC/ABS - Carbon CFRT®	PA6 – Carbon CFRT®
Painting			
In-mold Decorating			
Printing			
Labels & Decals			
Sublimation			
Texturing			



-  This has been preliminarily tested and should work
-  This has not been tested and needs development
-  This is not recommended at this time

### 16. Machining & Finishing

The goal of compression molding CFRT is to minimize or eliminate the need for a part to be machined or finished. If there is a need to machine or finish the part it should be known that CFRT materials are much stronger and stiffer than their plastic analogs. The following chart is a quick reference for the operations that can be used to machine or finish a compression molded CFRT part.

Operation Description	Accept  Reject 
Drilling	
Tapping	  Depends on material
Cutting	
Punching, Blanking and Die Cutting	
Milling	
Polishing / Sanding	
Bonding, Welding	  Depends on Material
Trimming, Edge Finishing and Flash Removal	
Threaded Insert Installation	  Depends on Material

## 17. Structural Design

CFRT material is a laminated composite material customized to the customer's requirements. For this reason there are no set material properties as used in magnesium or plastic part design. For a quick review of CFRT materials the following basic review has been included.

- **Merriam-Webster Online Dictionary Definition of Composite Material**
  - *"solid material which is composed of two or more substances having different physical characteristics and in which each substance retains its identity while contributing desirable properties to the whole"*
- **CFRT is a Laminated or Layered Composite**
- **Each Layer is called a Lamina**
- **Each Lamina Contains**
- **Constituent Materials**
  - **Thermoplastic Resin**
    - PMMA, PP, PE, ABS, PA66, PA12, PC, PC-ABS, PETG, PET, Ultem, PPS, PU, PBT
  - **Fiber**
    - Glass, Carbon, Kevlar (common)
    - Basalt, Ceramic, Stainless Steel
      - Fiber in each layer can be
        - Uni-Directional
        - Fabric / Woven
        - Non-woven
- **CFRT Multi-directional Engineering Properties**
  - $E_x, E_y, E_z, G_{xy}, S_x, S_y, S_z$
  - $\rho, \nu_{xy}, \nu_{xz}$ ,

