How to Build an Audiophile Car Stereo System, part 7

Door Fabrication

by **Jon Whitledge**, Jan 05, 2011

Introduction

Previous articles discussed the overall design of my system and the importance of properly anchoring the front sound stage. The focus of this article, Part 7, will be on the fabrication process of the door enclosures and the door panels.

Fabrication of the sealed door enclosures

The design and fabrication of the sealed door enclosures was influenced by many challenges. Foremost among these was achieving an enclosure design of sufficient volume. From my calculations in Part 4, the smallest feasible volume was determined to be 21.44 liters (0.76 ft^3). Another of the many challenges involved mounting the enclosure to the door structure. I believed the use of rubber vibration isolators, mounted at the extreme edges of the door structure, where the door was maximally rigid, would sufficiently minimize the transfer of enclosure vibrations and resonances to the door structure. Because the doors have limited load-carrying capability, it was important to strike the best balance between enclosure rigidity and weight. From Part 5, I knew the use of fiberglass composite, comprised of woven roving, would provide the highest specific stiffness and strength. Lastly, it was important to use damping materials to maximum advantage. Figures 1 through 21, inclusive, show the fabrication steps typical for a typical door enclosure.

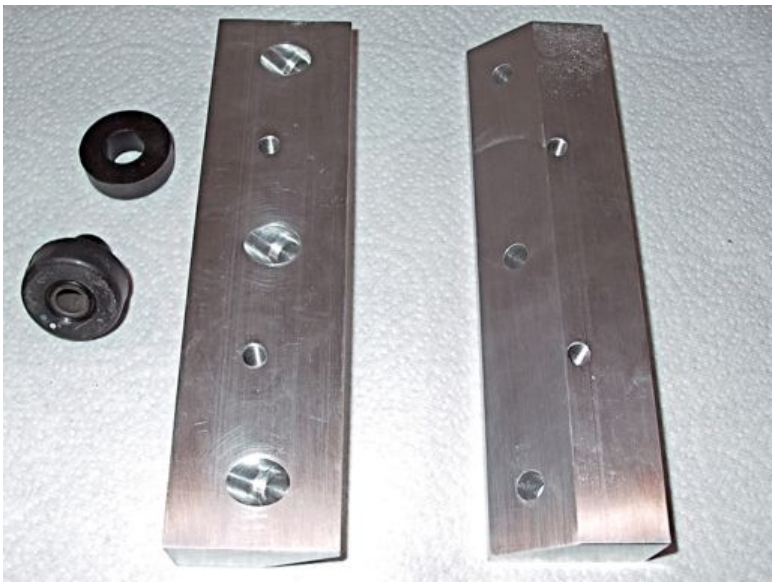

Figure 1. Aluminum brackets were machined and mounted to the rear edges of the doors to secure the rear edges of the door enclosures. One of the four rubber isolators is shown.

Figure 2. Five M8 x 1.25 rivet nuts were installed in each door. The pullout strength of each rivet nut was 15.7 kN (3,522 lb).

Figure 3. The door enclosures' back panels were formed from fiberglass composite comprised of woven roving. The complex curvature and ribs were intended to increase stiffness. The four mounting holes accommodated the rubber isolators.

Figure 4. Loudspeaker transducer mounting rings were machined from 1-inch thick (nominal) MDF. An additional MDF ring was bonded to the machined rings to increase the overall thickness to 50.8 mm (2 in). M4 x 0.7 t-nuts were bonded to the backside of each ring, configured to match the loudspeaker transducer's bolt circle.

Figure 5. With the back panel mounted in its rubber isolation system, the loudspeaker transducer was appropriately aimed using my proprietary articulating mounting fixtures. Cascade Audio's VB-2 damper was applied to the inner door "skin", while several layers of Cascade Audio's VMAX was applied to the inner surface of the outer door skin.

Figure 6. A magnetically attached jig, equipped with a laser gun sight, provided for precise aim. Notice the two red dots on the back edge of the tape measure, resting on the center console, were perfectly coincident.

Figure 7. The mold for the front half of the enclosure was formed from foam blocks and KLEAN KLAY® (Art Chemical Products, visit http://www.kleanklay.com). The back panel and the MDF ring were protected with masking tape to prevent the absorption of clay residue.

Figure 8. The driver's seat and seat swivel base restricted both the upward aim of the loudspeaker transducer and the protrusion of the enclosure into the cockpit area. Sufficient clearance to all objects was required in order to allow appropriate clearance for the door panel.

Figure 9. The MDF loudspeaker transducer mounting ring was appropriately shaped to accommodate layers of fiberglass composite. The mold was fashioned to allow room for a flange, which would allow the two molded halves to be bolted together. Liberal amounts of mold release were applied to the KLEAN KLAY® and masked surfaces.

Figure 10. The first layers of fiberglass composite secured the MDF loudspeaker transducer mounting ring into position, enabling the mounting fixtures to be removed.

Figure 11. Additional KLEAN KLAY® was used to fill in the voids left by the mounting fixtures.

Figure 12. Numerous layers of fiberglass composite, comprised of 8.8 oz. twill woven roving and polyester laminating resin, were applied until the enclosure wall thickness reached about 12 mm (0.472 in), in accordance with the guidelines established in Part 5.

Figure 13. The KLEAN KLAY® and foam blocks were removed from the molded part. Notice the perfectly formed flange along the outside edge of the enclosure half. All fiberglass composite surfaces that were in contact with KLEAN KLAY® and mold release were thoroughly cleaned with acetone to remove any traces of residue.

Figure 14. The edges of the front half of the enclosure were trimmed and sanded to match the edges of the back panel.

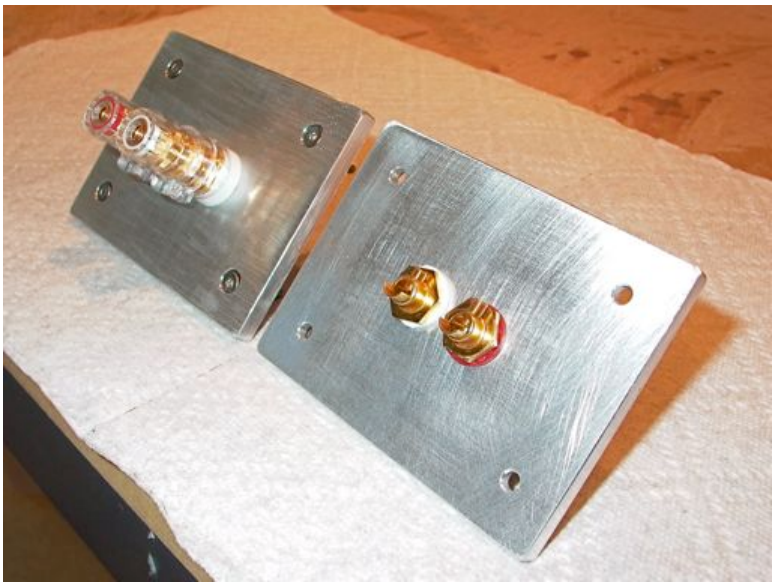

Figure 15. Binding post plates were machined from ¼-inch (6.35 mm) thick 6061-T6 aluminum, into which WBT binding posts were mounted.

Figure 16. Twenty-five equally-spaced M6 x 1 stainless steel socket head cap screws ("SHCSs"), in conjunction with washers, lock washers, and nylon locking nuts were used to bolt the two enclosure halves together. The mating surfaces were sealed with silicone caulk. The binding post plate was secured to the enclosure using four M4 x0.7 stainless steel SHCSs, sandwiching a 1/8-inch (3.18 mm) thick Sorbothane™ gasket. Custom loudspeaker cables were fabricated using Kimber Kable's 4TC bulk loudspeaker cable and WBT's crimp sleeves and spade connectors. The enclosure, and its rubber isolators, was secured to the door with four M8 x 1.25 SHCSs. The pile of fibrous damping material, manufactured by Acousta-Stuf, was representative of the amount used in the enclosure.

Figure 17. The MW180 loudspeaker transducer was installed in the enclosure for preliminary listening evaluation and tuning. The center of the factory door panel was cut away to make room for the enclosure.

Figure 18. Ten successive applications of Cascade Audio's VB-1X were applied to the interior surfaces of the enclosures' front and back panels.

Figure 19. Seven successive applications of Cascade Audio's VB-1X were applied to the exterior surfaces of the enclosures' front and back panels. The total thickness of VB-1X applied to the inside and outside surfaces of the enclosures was nearly equal to the thickness of the fiberglass composite substrate.

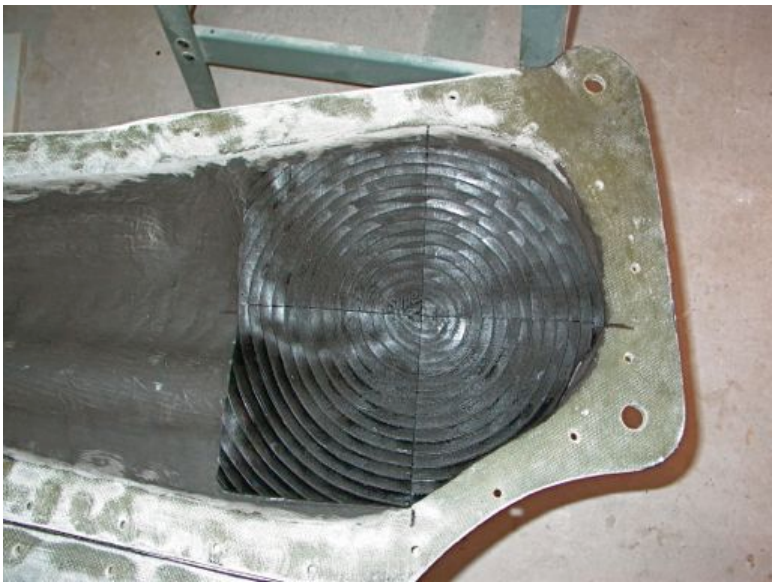

Figure 20. Cascade Audio's Deflex Power Pad was custom cut and bonded to the inside surface of each back panel using cyanoacrylate gel adhesive.

Figure 21. Finished door enclosure installation. The finished weight of each enclosure was about 35 lb (156 N).

Fabrication of the door panels

The door panels were designed to be completely isolated from the door enclosures to minimize the transmission of vibrations. Figures 22 through 34, inclusive, show the fabrication steps typical for a typical door panel.

Figure 22. The mold for the new door panel was fashioned from plywood and KLEAN KLAY®. Duct tape was used to protect the underlying structures from KLEAN KLAY® residue.

Figure 23. The finished door panel mold was liberally coated with mold release.

Figure 24. Blue masking tape and clear plastic sheet was used to protect surfaces from errant resin. The first four to six layers of fiberglass composite, comprised solely of 8.8 oz. twill woven roving and polyester laminating resin, were applied on the door mold and allowed to cure overnight.

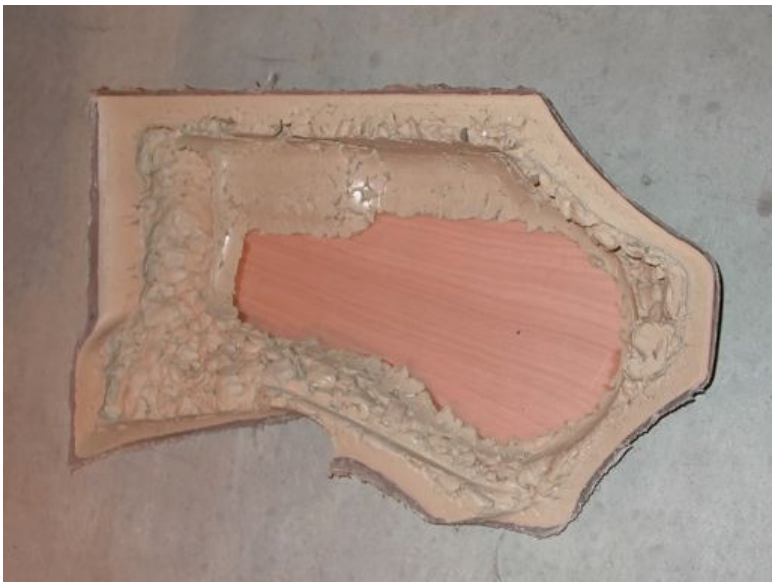

Figure 25. The molded door panel was removed from the door, but the mold came with it. The KLEAN KLAY® and the wood form were subsequently removed. KLEAN KLAY® residue was thoroughly removed using acetone. The inside surface of the molded part was sanded with 36-grit sandpaper and again thoroughly cleaned with acetone.

Figure 26. Additional layers of fiberglass composite, comprised of 8.8 oz. twill woven roving and polyester laminating resin, were applied to the molded panel until the thickness reached at least 6 mm (0.236 in).

Figure 27. The edges of the panel were carefully cut to match the contours of the factory door panel. The hole for the loudspeaker transducer was also cut.

Figure 28. The factory door panel, comprised of a PP/EPDM copolymer, was sanded with 36-grit sandpaper and primed with 3M's Duramix™ TPO Adhesion Promoter. The fiberglass panel was bonded to the factory door panel using 3M's Duramix™ 4036 Thermoplastic Olefin TPO Repair adhesive. After the adhesive cured for 24 hours, the door panel assembly was removed and a liberal fillet of Duramix™ 4036 was applied to the inside of the bond line.

Figure 29. A substantial fiberglass composite gusset was added to bridge, and further reinforce, the bond between the factory door panel and the fiberglass composite door panel.

Figure 30. Aluminum peel rivets were installed to augment the adhesive bond with a mechanical bond.

Figure 31. The fiberglass composite panel was filled and contoured with Evercoat®'s Rage Gold® body filler. 3M's Duramix™ 4058 E-Z Sand Plastic Finishing Paste was used to fill the transition from the PP/EPDM door panel to the fiberglass composite panel. The entire door panel was block-sanded with 80-grit sandpaper in preparation for primer.

Figure 32. A two-component polyester high-build primer was sprayed onto the door panel. The primer was block-sanded with 320-grit sandpaper prior to the application of the color-matched, textured, two-component finish. While I did the sanding, Jorge Perez at Tri-City Paint (visit www.tcpglobal.com) expertly sprayed the parts with primer and paint. If you live in the San Diego area, I highly recommend Jorge's work.

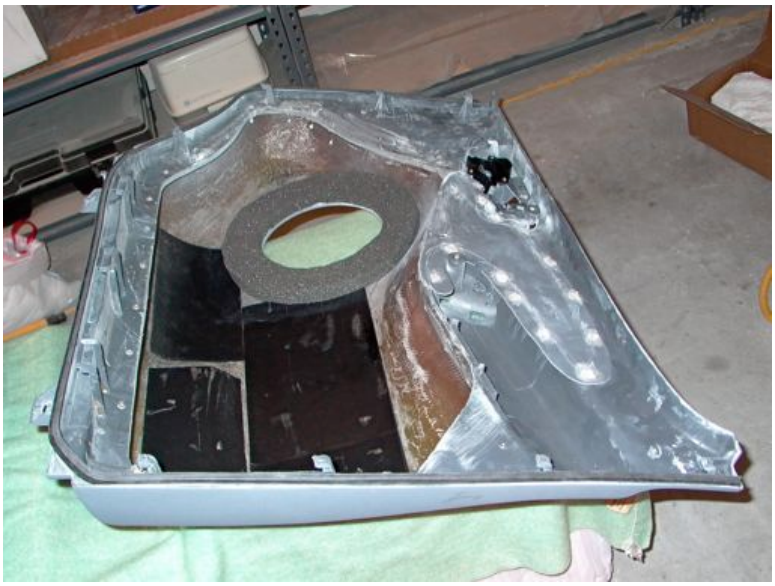

Figure 33. A ring of acoustical foam was applied to the inside of the door panel to act as a gasket between the door panel and the loudspeaker transducer. The gasket covers six M4 x 0.7 t-nuts, adhesively bonded to the inside of the door panel with Duramix™ 4040, configured to form the bolt circle for the loudspeaker transducer grill. Layers of VMAX were applied to the inner surface of the door panel.

Figure 34. View of the finished door panel with Dynaudio's MW180 speaker grill installed. The total added weight of the isolated, highly damped, rigid, loudspeaker enclosure and door panel was about 50 lb (222 N)!