



Designation: E3086 – 17

Standard Practice for Creating Appliques for Use in Testing of Nonplanar Soft Body Armor Designed for Females¹

This standard is issued under the fixed designation E3086; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice specifies a procedure for creating appliques (that is, build-up of clay) for use behind nonplanar, soft body armor test items and affixing the appliques to the clay block.

NOTE 1—This practice describes a single applique shape; additional shapes may be described in other standards.

1.2 The purpose of this practice is to specify critical parameters for creating appliques in order to improve consistency of the test setup between laboratories.

NOTE 2—In the past, testing of nonplanar soft armor has been done either with an unspecified buildup of clay behind the test item or with the test item pressed flat against the clay block.

1.3 This practice is applicable only to nonplanar soft body armor designed for females.

1.4 This practice is not applicable to hard armor test items.

1.5 This practice is primarily directed toward test laboratories but may be applicable to body armor manufacturers, researchers, and end users performing ballistic-resistance testing of body armor.

1.6 In this practice, “other standards and specifications” and “unless specified elsewhere” refer to documents (for example, military standards, purchase specifications) that require the use of this practice. Purchasers and other users are responsible for the “other standards and specifications” and for specifying any requirements that supersede those of this practice.

1.7 *Units*—The values stated in SI units are to be regarded as standard. Where appropriate, inch-pound units are included parenthetically for information purposes.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

¹ This practice is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.04 on Personal Protective Equipment (PPE).

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2. Referenced Documents

2.1 *ASTM Standards*:²

E3004 Specification for Preparation and Verification of Clay Blocks Used in Ballistic-Resistance Testing of Torso Body Armor

E3005 Terminology for Body Armor

3. Terminology

3.1 For terms not defined in this practice, the following definitions of Terminology E3005 apply: *backface deformation*, *backing assembly*, *backing fixture*, *backing material*, *body armor*, *hard armor*, *nonplanar*, *soft armor*, *test item*, and *test threat*.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *applique*, *n*—a three-dimensional item molded from backing material, that is shaped and sized for testing or conditioning a nonplanar test item.

3.2.1.1 *Discussion*—Some appliques are designed for the purpose of filling the entire space behind a nonplanar test item; other appliques are designed to assess features of a nonplanar test item.

3.2.2 *applique pattern*, *n*—a replica of the final product (that is, applique) used for preparing the applique mold cavity.

3.2.3 *mold box*, *n*—a frame used in creation of the mold to contain and give shape to fluid material while it sets up.

4. Significance and Use

4.1 U.S. Department of Defense and U.S. Department of Justice standards for assessing the performance of ballistic-resistant torso body armor require the use of backing assemblies made with Roma Plastilina No. 1[®]. The creation of appliques behind nonplanar soft armor test items must be done in a consistent manner to reduce variability within and between laboratories.

4.2 This practice is applicable for certification testing or for research and development testing.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

5. Equipment and Materials

5.1 The following equipment and materials are required for making appliques defined by this practice:

5.1.1 *Clay*—Unless specified elsewhere, the clay shall be ROMA Plastilina No. 1® modeling clay.

5.1.2 *Backing Assembly*—The backing assembly and clay used for building up behind nonplanar test items shall meet the requirements of Specification E3004.

5.1.3 Applique pattern.

5.1.4 Items for applique formation:

5.1.4.1 Mold box.

5.1.4.2 Mold-grade silicone rubber, Shore 15A hardness.

5.1.4.3 Release agent.

5.1.5 Draw knife or similar striking device.

5.1.6 Oven for heating clay.

5.1.7 Oven for storing appliques before use in testing.

6. Procedure for Making Applique Molds

6.1 There are five possible sizes for appliques, and each applique size requires a separate mold.

6.2 Creating the mold requires a mold box, an applique pattern, and silicone. The size of the mold box and applique pattern are dependent on the size of the applique that is required.

6.3 Create an applique pattern whose top surface conforms to the equation below and whose base is formed by the x-y plane (where z = 0). In this shape, x, y, and z represent the length, width, and height respectively:³

$$z = \frac{513b(x - a)}{640a} \left(\left(\frac{x}{a} \right)^2 + \left(\frac{y}{b} \right)^2 (e^{0.005x}) - 1 \right) \quad (1)$$

6.4 Table 1 provides the values of a and b to be used in Eq 1 for the corresponding applique sizes. An example of a 3D printed applique pattern is shown in Fig. 1.

³ The equation provided here is a simplified version of the equation described, with its derivation, in the following paper: Stoe, D., Otterson, D., (2016) *Research, Testing, and Standards for Body Armor Designed for Women Law Enforcement Officers*, Personal Armour Systems Symposium, Amsterdam, Netherlands, September 20, 2016.

TABLE 1 Parameters for Different Applique Sizes

Applique Size Designation	a (mm)	b (mm)
A-1 (smallest)	69.189	53.222
A-2	76.740	59.031
A-3	84.291	64.839
A-4	91.842	70.648
A-5 (largest)	99.393	76.456

NOTE 3—Tolerances on the applique pattern, if required, will be specified in other standards or specifications.

6.5 Build a mold box based on the approximate inside dimensions provided in Table 2. The box shall be made from a rigid material, such as metal or wood.

NOTE 4—The mold box does not require a top or a bottom.

6.5.1 Place the mold box on a flat, rigid, non-porous surface (for example, a table top), and place the applique pattern into the mold box, relatively centered and flat side down. See Fig. 2 for a graphic showing the mold box and applique pattern in position on a flat surface.

6.5.2 Coat the applique pattern with two coats of release agent applied at least five minutes apart or at timing specified by the manufacturer.

6.5.3 Fill the mold box completely with silicone, remove any excess at the top surface with a draw knife, and clean any silicone from the edges of the mold box.

6.5.4 Allow the silicone to cure per manufacturer instructions.

6.5.5 Turn the mold box over, and remove the applique pattern, but do not remove the mold from the mold box. An example of a completed mold is shown in Fig. 3.

7. Procedure for Creating the Applique

7.1 Using clay that has been heated and worked to make it more malleable, work the clay by hand into small pieces approximately the size of a golf ball.

7.2 Press one small piece into the deepest part of the mold and spread it across the surface, taking care to not introduce voids at the clay-to-mold interface.

7.3 Press another small piece of clay into the mold, taking care not to dislodge previously pressed in clay because the clay



FIG. 1 Example of 3D Printed Applique Pattern Resting on its Base

TABLE 2 Inside Dimensions of the Mold Box

Box Designation	Length	Width	Height
A-1	152 mm (6 in.)	121 mm (4¾ in.)	57 mm (2¼ in.)
A-2	165 mm (6½ in.)	133 mm (5¼ in.)	64 mm (2½ in.)
A-3	181 mm (7⅛ in.)	146 mm (5¾ in.)	70 mm (2¾ in.)
A-4	197 mm (7¾ in.)	159 mm (6¼ in.)	73 mm (2⅞ in.)
A-5	213 mm (8⅝ in.)	171 mm (6¾ in.)	79 mm (3⅛ in.)

tends to slip within the mold and must be held in place. Continue this process until the mold is filled with clay, and the clay extends beyond the surface of the mold.

7.4 Use a draw knife, or similar device, in contact with two parallel edges of the mold box to strike the clay to create a planar surface.

7.5 Invert the mold and remove the applique onto an appropriately sized flat surface on which the applique can rest during conditioning.

7.6 Voids apparent in the surface of the applique should be repaired by hand.

NOTE 5—Small imperfections in the clay surface are acceptable.

7.7 Condition the applique for a minimum of 3 h in a chamber having conditions as specified in Specification E3004.

8. Procedure for Affixing the Applique to the Clay Block

8.1 Remove two appliques from the conditioning chamber.

8.2 Unless the orientation and spacing of the appliques is specified in other standards or specifications, position the appliques on the clay block side-by-side with their bases touching. Fig. 4 shows one potential configuration of appliques installed on a clay block.

NOTE 6—For the purposes of exploiting perceived weak points, any in-plane rotation of the configuration shown in Fig. 4 is considered acceptable.

8.3 Hand form warm clay into a long, thin strip. Place the strip around the perimeter of each applique at the interface with the clay block, and press the clay strip into the interface to ensure that the appliques remain adhered to the clay block during testing.

NOTE 7—Care is required to ensure that the shape of the applique is not significantly changed during affixing it to the clay block.

9. Keywords

9.1 ballistic testing; nonplanar; soft body armor

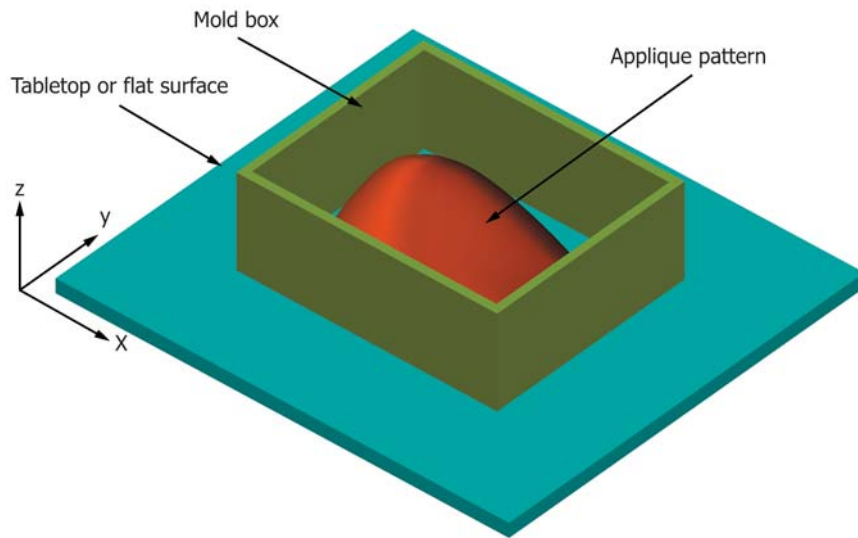


FIG. 2 Mold Box and Applique Pattern in Position on a Flat Surface (Applique Pattern is Resting on its Base)

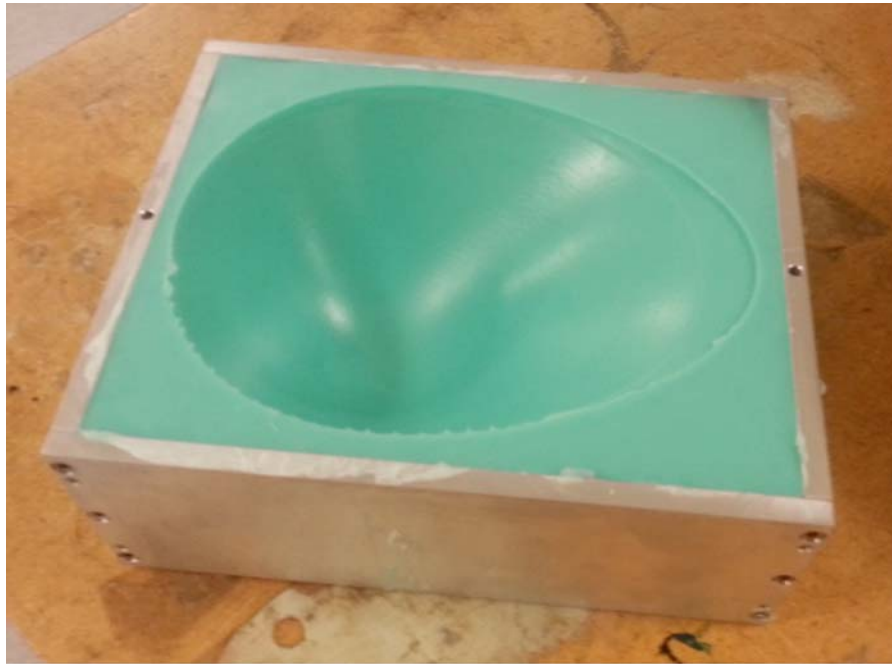


FIG. 3 Example of a Completed Mold

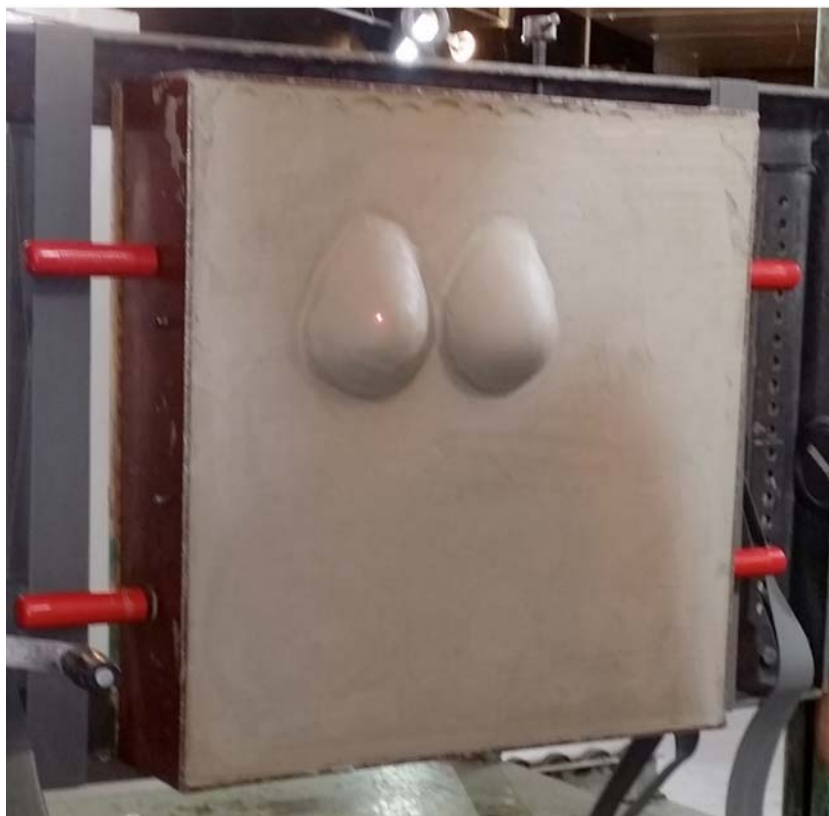


FIG. 4 Photograph of Appliques Installed on a Clay Block

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