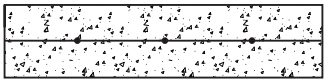
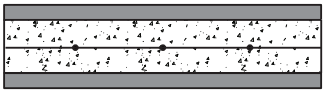
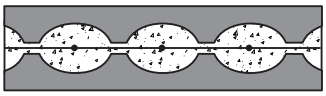
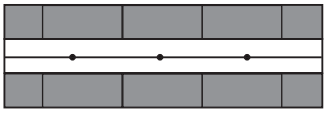
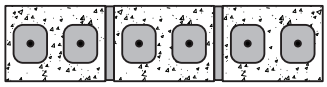
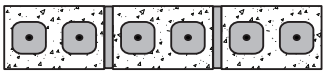
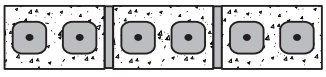
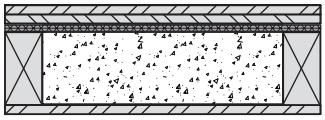
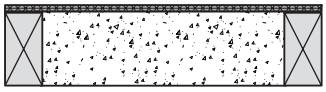
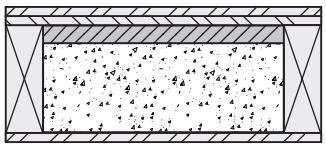
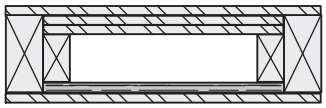
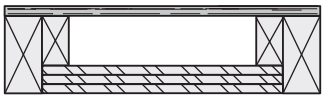
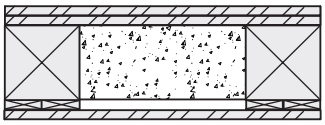
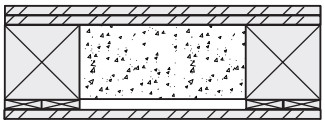
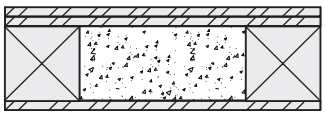
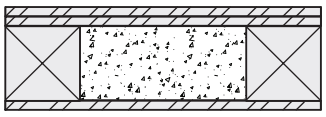
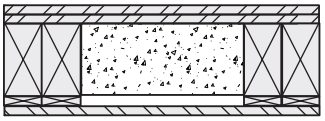
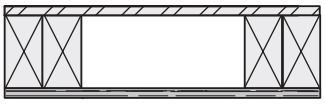
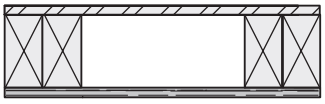
Appendix E
Wall Sections That Passed Previous Missile Impact Tests

The following sheets document the performance of wall sections that passed previous missile impact tests (standards held by the first edition of FEMA 361). Information is provided for each wall section and contains a description of the wall construction (e.g., stud wall with plywood and/or metal sheathing, stud wall with concrete infill, reinforced CMU wall, insulating concrete form [ICF] wall), cross-section illustration, test missile speed, and description of damage. It is important to note that the inclusion of a wall section here does not signify that the section will necessarily pass the current missile impact standard tests, or give the wall sections listed as passing previous tests certification to the more recent standards upheld by this publication and the ICC-500. However, these sections have passed tests held to previous standards that, in some cases, may have been more stringent than current standards. This section is to be used merely as a method of determining which wall sections could be considered for use in a safe room application from the knowledge gained from previous testing performed.

Type of Wall Section (Target)	Description of Wall Section	Missile Speed (mph)	Description of Damage
Reinforced concrete wall, at least 6 inches thick, reinforced with #4 rebar every 12 inches (both vertically and horizontally)		100+	This target has been proven successful in previous tests.
Insulating concrete form (ICF) flat wall section at least 4 inches thick reinforced with #4 rebar every 12 inches (both vertically and horizontally)		100+	This target has been proven successful in previous tests.
Insulating concrete form (ICF) waffle grid wall section at least 6 inches thick reinforced with #5 rebar every 12 inches vertically and #4 rebar every 16 inches horizontally		100+	This target has been proven successful in previous tests.
Brick cavity wall reinforced with #4 rebar every 12 inches and concrete infill		100+	This target has been proven successful in previous tests.
8-inch CMU reinforced with concrete and #4 rebar in every cell		100+	The target was impacted over 30 times with the design missile. This was done for demonstration purposes. Only the first (verification) test was conducted as part of FEMA 320.
6-inch CMU reinforced with concrete and #4 rebar in every cell		103.4	The missile impacted the target at a mortar joint. The target was cracked from the point of impact to the top of the target both in the front and in the back. The mortar spalled out of the joint on the back of the target.
6-inch CMU reinforced with concrete and #4 rebar in every cell		111.3	The target was impacted at a vertical mortar joint. There was a 1/16-inch indentation on the impact face, but no visible damage to either side of the target.

Type of Wall Section (Target)	Description of Wall Section	Missile Speed (mph)	Description of Damage
2x4 stud wall with CD grade plywood, 14-gauge ½-inch expanded metal, and concrete infill		105.0	The missile impacted 4 inches to the left of a stud. No damage was visible on the back of the target.
2x4 stud wall with CD grade plywood, 14-gauge ½-inch expanded metal, and concrete infill		106.1	The missile impacted 1½ inches to the left of a stud. No damage was visible on the back of the target.
2x4 stud wall filled with concrete with no plywood and 14-gauge ½-inch expanded metal on the non-impact face		107.7	The missile imade partial contact with the stud. The concrete was cracked around the impact area.
2x4 stud wall filled with concrete with no plywood and 14-gauge ½-inch expanded metal on the non-impact face		107.2	The missile imade partial contact with the stud. The concrete was severely damaged, and a 4-inch deflection on the back of the target was observed.
2x4 stud wall filled with concrete with no plywood and 14-gauge ½-inch expanded metal on the non-impact face		107.1	The missile impacted the concrete. No damage was visible.
4-inch concrete block in a 2x6 stud wall with 1½ inches polystyrene between block and two layers of ¾-inch CD grade plywood		111.3	The missile penetrated the target. There was no visible damage to the back side of the target.
Double 2x4 stud wall with 4 layers of ¾-inch CD grade plywood and 14-gauge steel on the back face		106.6	The target was impacted next to a stud. Several heads of screws were popped off the back of the target. The steel had 1 inch of deformation.
Double 2x4 stud wall with 4 layers of ¾-inch CD grade plywood and 14-gauge steel on the back face		104.9	The target was impacted on the stud line. The stud was cut in two. No deformation was visible on the back side.
4 layers of ¾-inch plywood with 14-gauge steel insert with spacers between the insert and the back face		109.4	The missile penetrated the target 1½-2 inches. A crack in the plywood on the back face caused bending, but total separation did not occur.

Type of Wall Section (Target)	Description of Wall Section	Missile Speed (mph)	Description of Damage
4-inch concrete block in a 2x4 stud wall with two layers of ¾-inch CD grade plywood, and one layer of 14-gauge ½-inch expanded metal on the non-impact side and one layer of plywood on the impact side		106.7	¾ inch of penetration. There was no visible damage to the non-impact side.
2x4 stud wall with 3 layers of ¾-inch CD grade plywood inserts with 14-gauge metal on the non-impact side		105.7	The first insert of plywood failed in shear while the interior two failed in bending. The studs started to be torn in half, and there were 3 inches of deformation of the 14-gauge metal.
4x4 stud wall with 1x4s on the studs, containing 4-inch concrete block, gypsum board infill, and one layer of ¾-inch CD grade plywood on the impact face and two layers on the non-impact face		111.2	The missile impacted the stud and ½ inch of deflection occurred on the non-impact side.
4x4 stud wall with 1x4s on the studs, containing 4-inch concrete block, gypsum board infill, and one layer of ¾-inch CD grade plywood on the impact face and two layers on the non-impact face		106.5	Missile penetrated the target, but did not perforate the target when it impacted at the interface between the block and the 4x4 stud.
4x4 stud wall with 4-inch concrete block, with one layer of 3/8-inch CD grade plywood on the impact face and two layers of ¾-inch CD grade plywood on the non-impact face		115.7	There was no missile penetration.
4x4 stud wall with 4-inch concrete block, with one layer of 3/8-inch CD grade plywood on the impact face and two layers of ¾-inch CD grade plywood on the non-impact face		109.0	The missile impacted the interface between the block and the 4x4 stud, perforating the target 3 feet.
Double 2x4 stud wall with furring, containing 4-inch block, with two layers of ¾-inch CD grade plywood on the non-impact face, one layer on the impact face, and a layer of 3/8-inch gypsum board on the impact face		100.7	The missile impacted next to the stud. There was ½ inch of deformation and cracking on the non-impact side.

Type of Wall Section (Target)	Description of Wall Section	Missile Speed (mph)	Description of Damage
Double 2x4 stud wall with one layer of 12-gauge steel on the impact side and one layer of ¾-inch CD grade plywood on the non-impact side		105.2	The missile impacted next to the stud and was destroyed.
Double 2x4 stud wall with one layer of 12-gauge steel on the impact side and one layer of ¾-inch CD grade plywood on the non-impact side		103.6	The missile impacted next to the stud and was destroyed.