GENERATOR SHELTER IMPACT TEST REPORT
(.08 Material)

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Executive Summary

Per the request of the Division of Emergency Management and the Department of Community Affairs, Barkley Consulting Engineers, Inc. supervised a modified large missile impact test on generator enclosures (.08 material). The purpose of the test was to determine if the JRS Custom Fabrications, Inc. supplied enclosures would meet the modified (see modification section, page 4) large missile impact test. The tests were conducted at JRS Custom Fabrications, Inc., 168 NW 68th Avenue, Ocala, FL on May 16th & 17th 2007. This summary only discusses the .08 material.

The .08 material was tested connected with both screws and VHB tape. The .08 material did pass the modified impact test.

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Introduction

Modifications to procedures of the ASTM E 1996 and SSTD 12 testing standards were specified by Florida Division of Emergency Management (DEM) in agreement with Florida Department of Community Affairs (DCA), for the purposes of this project (see page 4 of this report for specifics). Barkley Consulting Engineers (BCE) was directed by DEM / DCA to observe this testing, and to report the observations and results. It is the understanding of BCE that DEM / DCA will present this report for consideration by the Authority Having Jurisdiction (AHJ) within Department of Education (DOE). It is also Barkley Consulting Engineers understanding that the louvers and other assemblies have been tested and signed and sealed shop drawings by the respective manufacturers will be provided to DOE as needed.

The Florida Department of Community Affairs and the Division of Emergency Management requested the testing of the generator panels. Per the modified procedures of the ASTM E 1996 and SSTD 12 testing standards, multiple panels from a full generator enclosure were impact tested for wind borne debris. The fabrication and impact testing of the panels were conducted at JRS Custom Fabrication in Ocala, FL, with the test being conducted under the supervision of Douglas Barkley, MS, PE. and Bryant McKinnie of the Division of Emergency Management.

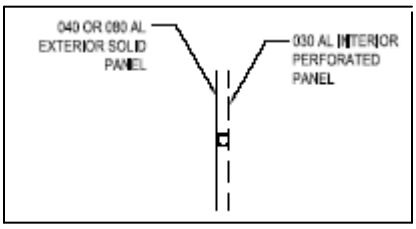
The test conducted was the large missile impact test only as the small missile impact test only applies for materials installed 30 feet above grade. No fatigue test was required by the modified testing procedure and therefore was not conducted. The roof panel was only impacted once as the components of these panels are a thicker 0.090 in lieu of 0.08 material.

Constructed with two layers of aluminum sheets, separated by “rigid” supports, and connected by either screws or adhesive, the housing panels were tested for their material and connection capacity when subjected to large missile impact. The aluminum used for the test panels was 080 AL for the exterior sheet (unless noted otherwise) and a perforated 030 AL for the interior sheet, as shown in Figure 1. The following table lists the sizes and the materials used for the panels that were tested.

Table 1. Test Panel Descriptions

Specimen Description	Size
S8 Panel Screws, 080 AL	4'-0" x 0'-7"
	4'-0" x 4'-0"
	4'-0" x 8'-0"
DA8 Panel Door, Adhesive, 080 AL	3’-0” x 6’-0”
RP Panel Roof Panel, 090 AL	2’-0” x 4’-0”
N.B. Panel No insulation or backing, aluminum skin only	4'-0" x 4’-0”

Figure 1. Wall Section of Generator Shelter



Impact Test – Modification of SSTD and ASTM Standards

The ASTM E 1996 and SSTD-12 standard specifications cover exterior windows, glazed curtain walls, doors and storm shutters used in buildings located in geographic regions that are prone to hurricanes. Under these testing standards, a specimen is subjected to an impact test followed by a by a cyclic pressure loading test which enables the specifying authority to examine the effects of internal air pressure on the specimen once the building envelope is breached. As a modification to the above listed testing standards, a cyclic pressure loading test will not be conducted during the testing of the generator shelter enclosures. Per these standards, a specimen must meet the acceptable criteria set forth in order for the specimen to provide the appropriate level of protection as an adequate component of a structure meeting criteria in hurricane prone areas.

Specimens being tested under the modified specification must be prepared by removing any excess material that is required for normal operation. Mounting the specimen in a pre-fabricated frame should model normal installation procedures with the similar number and type of hardware as specified by the manufacturer or as required. Once in place, the test specimen should not be moved at any time during the testing process. A minimum of three test specimens are required for a large missile impact test and the size shall be determined by the specifying authority. If it is not possible to test the entire assembly of a specimen, each type of panel must be tested to qualify the entire specimen.

For the impact testing sequence, a large missile must be chosen based on a level of protection and the wind zone criteria listed in the following table.

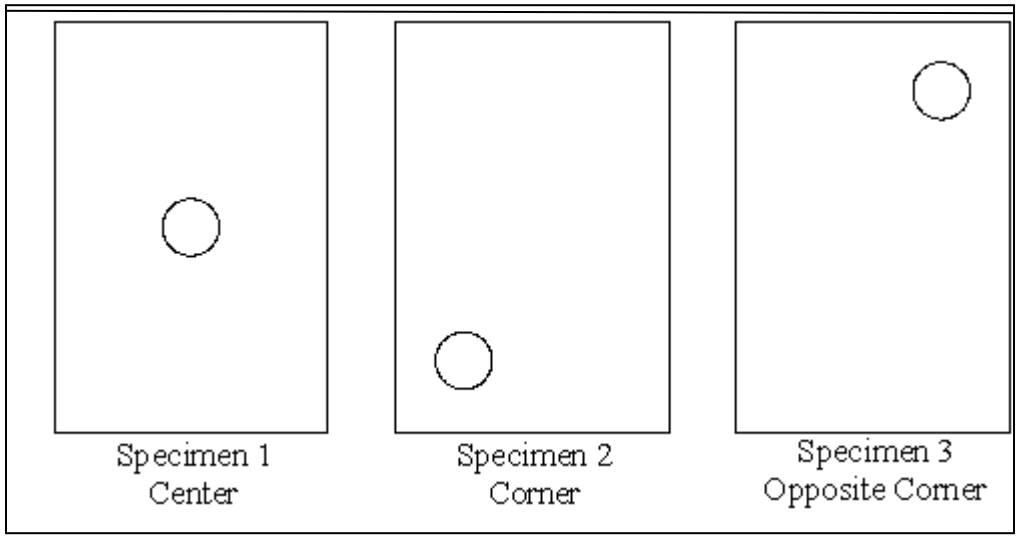
Protection Level	Enhanced Protection (Essential Facilities)		Basic Protection		Unprotected	
Assembly Height	≤ 30 ft	> 30 ft	≤ 30 ft	> 30 ft	≤ 30 ft	> 30 ft
Wind Zone 1	D	D	C	A	None	None
Wind Zone 2	D	D	C	A	None	None
Wind Zone 3	E	D	D	A	None	None
Note: For Missiles B, C, D, and E use also Missile A for porous shutter assemblies.						

Table 2. Missile Level Description

Enhanced protection includes structures designated as essential facilities required in an emergency. Unprotected facilities include structures that have low hazard to human life in a windstorm situation, with basic protection including all other structures that are not in an enhanced or unprotected facilities. The wind zones are broken into three categories where Zone 1 incorporated wind speeds between 110 - 120 mph. Zone 2 between 120 – 130 mph, and Zone 3 for all wind speeds greater than 130 mph.

Each of the three specimens needed for each missile test should be impacted with one of three impact locations shown in the following figure.

Figure 2. Impact Location for Large Missile Test



For one specimen, the impact location should be with the center of the missile within a 2.5 in radius circle located in the center of the specimen. An alternate impact location for a second specimen has the center of the missile impacting the specimen within a 2.5 in radius circle, which is located 6 in from the supporting members in a corner. A third impact location for a different specimen has the center of the missile impacting the specimen within a 2.5 in radius circle with the center of the circle located 6 in from supporting members at a diagonally opposite corner from previous impact location. These specified locations are mapped out for impact with the idea that cyclic loading pressures will follow. Even though cyclic loading pressures will not follow the missile impact, the general locations specified will still be used to obtain clear results in order to determine whether the specimen met the pass/fail criteria.

For the large missile impact test, the specimen should be oriented such that the missile will impact the exterior side of the specimen. The missile propulsion device needs to be a minimum distance of 1.5 times the length of the missile away from the exterior face of the specimen. A proper signal or warning system needs to be provided for testing authorities, or others, to signal when the testing is in progress as well as to prevent disruption of the testing sequence. Before the missile test commences,

the missiles weight should be taken and then loaded into the propulsion device. With the missile propulsion device aligned such that the missile will impact one of the specified impact locations, propel the missile at the specified impact speed in accordance to the missile criteria for each wind zone. Upon impact, a missile with a longitudinal axis shall be within $\pm$ 5% of a line normal to the specimen at the specified impact location. The specimen shall be examined for resistance to the impact or failure based on the established acceptance criteria after completion of the missile impaction sequence.

The acceptance criteria will vary depending on the type of specimen being tested. For fenestration assemblies and non-porous shutter assemblies, the passing criteria includes a specimens ability to resist a large missile impact such that a tear longer than 5in or an opening in which a 3 in diameter solid sphere can freely pass has not formed from the impact. When a porous shutter assembly is tested independently of a fenestration assembly, the missile shall not penetrate the innermost plane of the specimen. The specimen has failed the large impact test when the specimen does not pass both these requirements (tear and penetration).

Testing Procedures

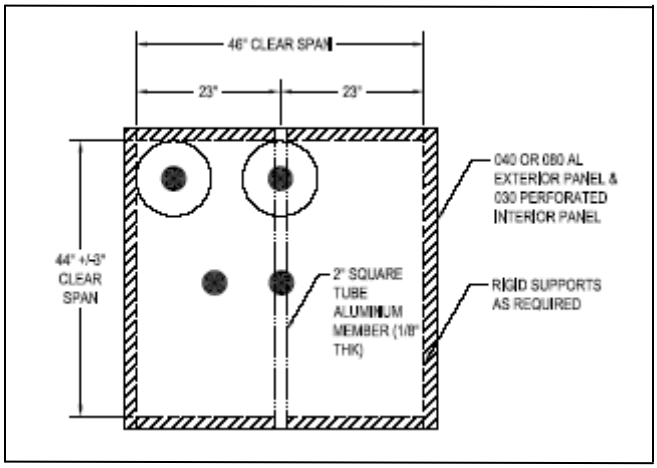
As an enclosure for generators which provide electricity to special needs shelters in the event of a hurricane, the test panels needed to be tested in compliance with the testing procedures and to meet the pass/fail requirements set forth by the modified impact test standards. With the impact test being performed at JRS, the testing set up was not as controlled as is typically required in a testing facility. Many measures were taken to provide an accurate testing environment due to the fact there was not a testing facility available.

The testing process began with assembling the various panels that were to be tested, as shown in the following figure.

Figure 3. 4'-0"x 0'-7" Test Panel Assembled for Testing

In accordance with the standard, the missile used for the impact test was a Missile Level D, which is a 9.0lb $\pm$ 0.25lb, 2 x 4 in, and 8 ft $\pm$ 4in long piece of lumber, with an initial impact speed of 50 ft/sec. The specimen and missile propulsion device were set up in accordance to the procedures listed in the previous chapter. Because the cyclic loading test did not follow the impact test on the specimens, a single specimen was subjected to multiple impacts until there was failure. For each specimen tested at JRS, there were multiple large missile impacts with increasing impact speeds. Typical impact locations of the test panel are shown in the following figure.

Figure 4. Typical Impact Locations for a 4’-0” x 4’-0” Test Panel



Results of Impact Test

The following tables list all tested panels and the speeds at which they were impacted.

Table 3. Test Results for Specimen 1

Specimen #1	***A8 Panel - 4'-0" x 0'-7"***		
Test #	Missile Type	Speed (mph)	Result
1	Large	36	Pass
2	Large	36	Pass

Table 4. Test Results for Specimen 2

Specimen #2	***D8 Panel - Door***		
Test #	Missile Type	Speed (mph)	Result
1	Large	38	Pass
2	Large	37	Pass
3	Large	37	Pass
4	Large	90	Fail

Table 5. Test Results for Specimen 3

Specimen #3	***A8 Panel - 4'-0" x 4'-0"***		
Test #	Missile Type	Speed (mph)	Result
1	Large	37	Pass
2	Large	35	Pass
3	Large	75	Fail

Table 6. Test Results for Specimen 4

Specimen #4	***Roof Panel***		
Test #	Missile Type	Speed (mph)	Result l
1	Large	35	Pass

Table 7. Test Results for Specimen 5

Specimen # 5	***S8 Panel - 4'-0" x 0'-7"***		
Test #	Missile Type	Speed (mph)	Result
1	Large	37	Pass
2	Large	35	Pass

Table 8. Test Results for Specimen 6

Specimen #6	***S8 Panel - 4'-0" x 8'-0"***		
Test #	Missile Type	Speed (mph)	Result
1	Large	37	Pass
2	Large	34	Pass
3	Large	37	Pass
4	Large	36	Pass
5	Large	75	Fail

Table 9. Test Results for Specimen 7

Specimen #7	***S8 Panel - 4'-0" x 4'-0"***		
Test #	Missile Type	Speed (mph)	Result
1	Large	38	Pass
2	Large	37	Pass
3	Large	65	Fail

Table 10. Test Results for Specimen 8

Specimen # 8	***N.B. Panel - 4'-0" x 4'-0"***		
Test #	Missile Type	Speed (mph)	Result
1	Large	36	Pass
2	Large	34	Pass

Additional Statements

6.1 Tape or Film Statement