Explosive fill pressures inside the bombs never exceeded 3 Kbars. The pressures in the Mk82 and Mk84 bombs showed no significant differences. Crushing of the bombs during impact with the magazine wall caused the highest pressures. Crushing of the acceptors dominated the pressure response of the explosive fills.

The case deformations of the Mk107 warheads were calculated for prototype magazine stowage (Table 4). The case deformations range from 24% to 29%. Based on flyer plate tests, Mk107 warhead casings rupture at 10% deformation. The Mk107 warhead was then expected to rupture and break up into debris during acceptor-to-acceptor impact, prior to reaching the magazine wall. Detonation was not predicted because explosive fill pressures never exceeded 4 Kbar.

Test Results versus Analytical Predictions

All thick-skin munitions (Mk80 series bombs and M107-155mm projectiles) suffered less than 5% deformation. This is lower than expected and is attributed to the conservatism of the analyses. For example, the analyses assume that 3 acceptors will remain aligned upon impact whereas in reality oblique impacts and separation are more likely, with less energy transfer and deformation.

Most of the thin-skinned munitions (Mk107 torpedo warheads and Mk55 mines) cracked, and several broke into various sized debris and burned, as predicted. None detonated.

Findings

This full scale test certified that sympathetic detonation will not occur in the HPM under the critical storage cell explosion hazard scenario.

CONCLUSIONS

From FY92 to FY96 NFESC developed and completed a series of one-third and full scale tests, as well as two full scale certification test to demonstrate and certify a non-propagation wall design capable of reducing loads on acceptor munitions below thresholds for sympathetic detonation. Analytical procedures were developed to evaluate the various wall concepts.

Desirable characteristics for a non-propagation wall were determined by analysis and demonstrated in the test series. The optimum wall cross-section includes a core composed of a dense granular material to reduce the wall velocity and kinetic energy. Reducing the wall velocity and kinetic energy mitigates the initial peak pressures and structural deformation of the acceptor. The granular material minimizes the momentum transfer from the wall to the acceptor. The low-strength, high porosity CBC wall cover limits the peak pressure during wall-acceptor impact and absorbs strain energy.

Good correlation was obtained between predicted and measured acceptor accelerations and velocities. This correlation provides confidence in the analytical approach for predicting donor loads, wall response, and acceptor response.

Two full scale cell wall tests demonstrated that the HPM storage cell and aisle wall concepts can prevent sympathetic detonation from a 10,000 pound NEW donor to worst case thick skin acceptor ordnance. The donor loads and acceptor orientations in this test are similar to those expected in the prototype HPM (the peak pressure and total impulse loads on the wall were equal to that expected in worst case HPM scenario because of the small cell size used in the full scale wall test).

Analytical calculations for the full scale HPM certification test with a 30,000 lb. donor showed the impulse load environment on the aisle and cell walls were similar. Sympathetic detonation was prevented for both the thick-case and thin-case acceptor munitions.

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TABLE 1—PROPERTIES OF CBC MATERIALS [10]

MATERIAL	GC2	S5	MBW50	MBW60
COMPRESSIVE STRENGTH (PSI)	1500	4500	1500	2500
DENSITY (LBS/FT^3)	35	55	52	65
POROSITY (%)	75	55	60	52
THICKNESS (IN)	3, 6, 12	18	18	18

TABLE 2 —PREDICTED AND MEASURED ACCEPTOR RESPONSES FOR ONE-THIRD SCALE CELL WALL TESTS

TEST	DONOR	WALL CROSS SECTION					ACCEPTOR ACCELERATIONS					ACCEPTOR VELOCITIES	
		ID	COVER* Thick. (in)	COVER* Mat. Type	COVER Thick. (in)	COVER Mat. Type	ID	Orientation **	AUTODYN LOW (kG)	AUTODYN HIGH (kG)	TEST (kG)	AUTODYN (m/s)	TEST (m/s)
1	400	I	8	steel	12	GC2	1	+		1.33	3.86	27	25
		I	8	steel	3	GC2	2	+	2.07	12	7.7	32	32
		II	8	steel	6	GC2	3	+		1.67	6	28	32
		II	8	steel	--	--	4	+		27	32	37	86
2	400	I	12	sand	12	GC2	1	+		1.74	4.8	30	30
		I	12	sand	3	GC2	2	+	2.9	15.2	17	37	50
		II	12	sand	6	GC2	3	+	2.5	4.5	9.2	33	23
		II	12	sand	--	--	4	+		22	18	39	35
3	400	I	8	steel	6	S5	1	+	2.07	12	5.8	35	27
		I	8	steel	3	S5	2	+		27	14	34	50
		II	12	sand	6	S5	3	+	2.90	15.2	15.5	38	29
		II	12	sand	3	S5	4	+		22	23	38	32
4	400	I	6	steel	6	S5	1	+	5	9	6	34	27
		I	6	steel	--	--	2	+		27		45	
		II	8	steel	6	GC2	3	//	5	-105		61	
		II	8	steel	--	--	4	//		115	45	29	75

* Steel grit: 270 pcf; sand: 105 pcf

** Acceptor orientation: + perpendicular to the wall, // parallel to the wall.

TABLE 3—PREDICTED AND MEASURED ACCEPTOR RESPONSES FOR FULL SCALE CELL WALL TESTS

TEST	Donor	WALL CROSS SECTION					ACCEPTOR ACCELERATIONS						ACC. VELOCITIES		
		ID	CORE* Thick (in)	CORE* Mat Type	COVER Thick (in)	COVER Mat. Type	ID	Orientation **	AUTODYN Low (kG)	AUTODYN High (kG)	Test gage A (kG)	Test gage B (kG)	AUTO DYN	Test gage A (m/s)	Test gage B (m/s)
#1	9861	G	24	steel	18	GC2	B1	+	1.6	5.2	1.8	1.8	71	65	60
		G	24	steel	18	GC2	B2	+	1.6	5.2	1.8	1.9	71		65
		G	24	steel	18	GC2	P1	//	4.4	68	16	14	63		
		G	24	steel	18	GC2	P2	//	76	72	15	13.5	63		
		G	24	steel	18	GC2	P3	//	75	75	17	18	63		
		S	24	steel	18	S5	B3	+	4.1	6.1	3.4		80	60	
		S	24	steel	18	S5	B4	+	4.1	6.1	3	3.7	80	70	50
		S	24	steel	18	S5	P4	//	13	115			70		
		S	24	steel	18	S5	P5	//	140	120			72		
		S	24	steel	18	S5	P6	//	150	150	15	18	73		
		A	96	sand	18	GC2	B5	//		6	1.8	2.1	53	27	40
		A	96	sand	18	GC2	B6	//		6	2.3	2.1	54	30	28
#2	9861	B	24	steel	18	GC2	B1	+	1.6	5.2	3.4	3.2	71	80	70
		B	24	steel	18	GC2	B2	+	1.6	5.2	2.8	2.75	71	75	70
		P	24	steel	18	GC2	P1	//	4.4	68	15	17	63	90	175
		P	24	steel	18	GC2	P2	//	76	72	14		63	140	
		P	24	steel	18	GC2	P3	//	75	75	11	11	63	60	100
		P	24	steel	18	GC2	P4	//	4.4	68	7.8			35	
		A	96	sand	18	GC2	B3	//		6	2.7	2.6	53	40	22
		A	96	sand	18	GC2	B4	//		6	3.8	4.2	54	48	44

* Steel grit: 270 pcf; sand: 105 pcf

** Acceptor orientation: + perpendicular to the wall, // parallel to the wall.

TABLE 4 —THICK-CASE AND THIN-CASE DEFORMATION RESPONSE, CERTIFICATION TEST

ACCEPTOR TYPE	ACCEPTOR LOCATION (a) (b)					
	1	2	3	4	5	6
Mk82 Bomb	0.24	0.30	0.26			
Mk82 Bomb	0.23	0.24	0.22	0.22	0.27	0.26
Mk84 Bomb	0.26	0.27				
Mk84 Bomb	0.23	0.29	0.29	0.22		
Mk107 Warhead	0.29	0.29	0.28	0.28	0.24	

(a) Acceptors are numbered in increasing order on distance from magazine wall
(b) Values are given as change in diameter divided by initial diameter, $\Delta D/D$.

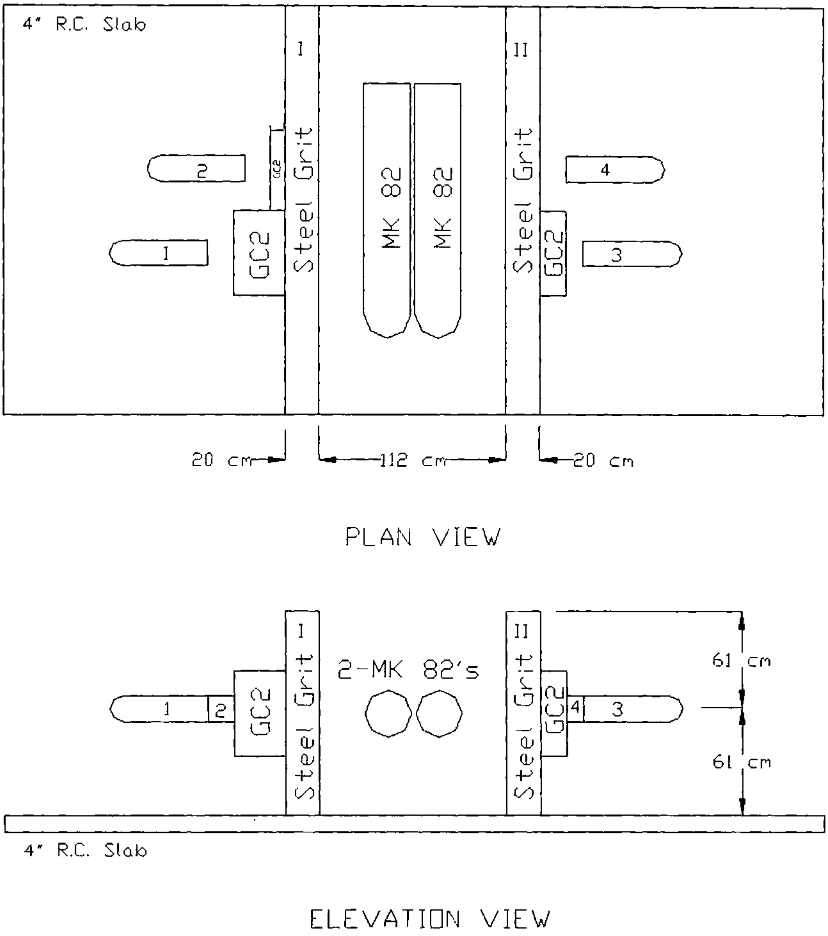

Fig. 1—Plan and evaluation views of typical third scale test

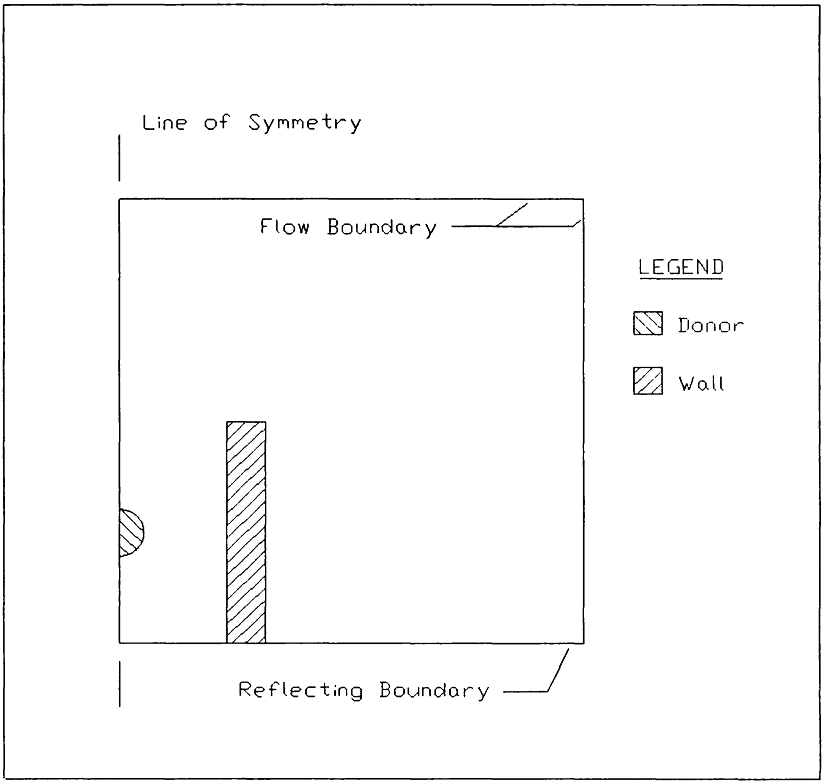

Fig. 2—AUTODYN-2D model of typical third scale test setup

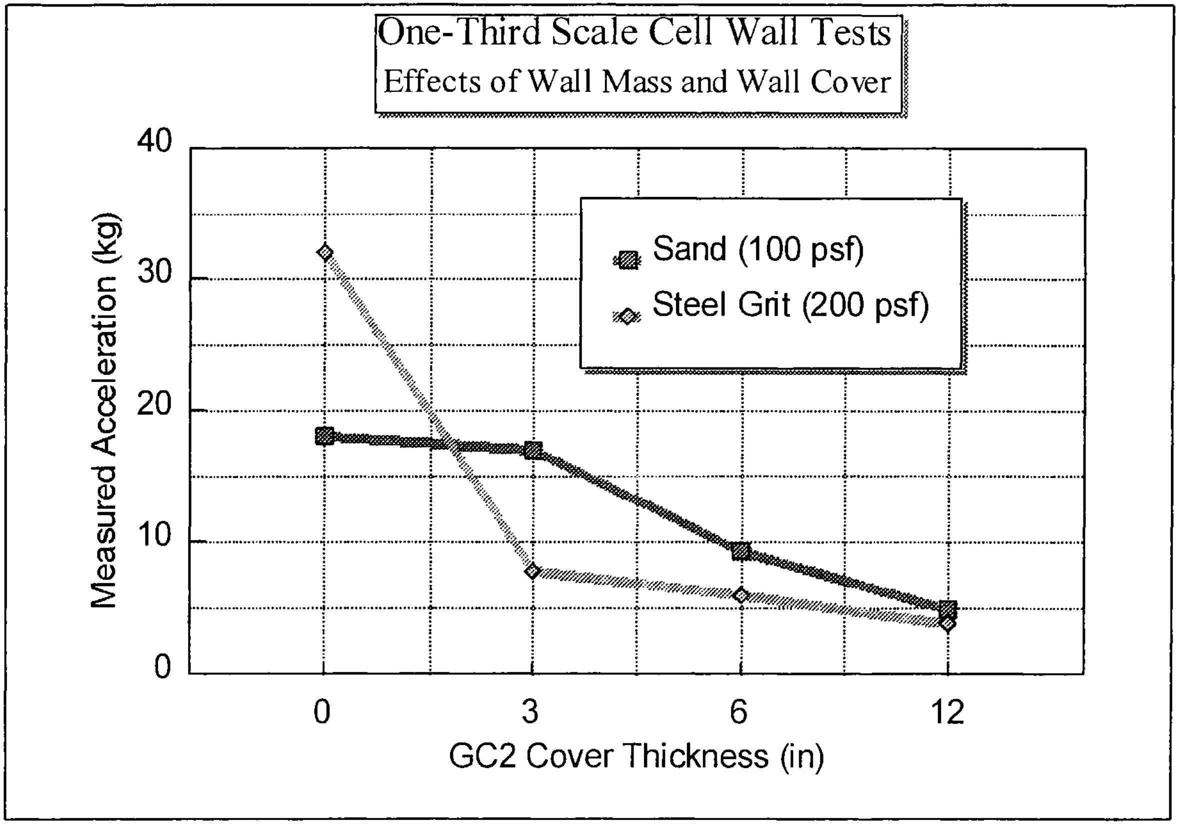

Fig. 3—Effect of cover on acceptor acceleration