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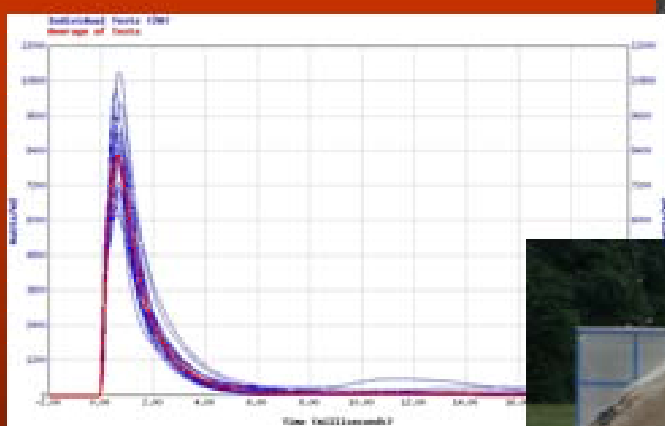
FINAL REPORT

PERFORMANCE CHARACTERIZATION STUDY NOISE FLASH DIVERSIONARY DEVICES (NFDDs)

This Project was Supported by Award No. 2002-DT-CS-K001 Awarded by the National Institute of Justice, Office of Justice Programs

Submitted to:

U.S. DEPARTMENT OF JUSTICE
Office of Justice Programs
Washington, DC 20531



Prepared By:

E-LABS INC.
Fredericksburg, Virginia 22408
OJP Vendor Number 541998019

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PERFORMANCE CHARACTERIZATION STUDY

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December 2003

EXECUTIVE SUMMARY

E-LABS, Inc. conducted characterization testing of less-than-lethal Noise Flash Diversionary Devices (NFDDs), provided by the ATF to quantitatively assess their primary functional performance and subjectively determine collateral effects upon common residential items and materials. This work was accomplished for the Office of Justice Programs (OJP) under the authority of National Institute of Justice (NIJ) Grant 2002-DT-CX-K001, ID Number 065595. These tests were undertaken to provide consistent, controlled functional data for select performance elements of these devices, not as a competitive assessment of brands, models, or types of NFDDs. It was not the intent of the sponsor or E-LABS to define the "best" NFDD from among these samples. Comparative listings of the results are offered merely as information, to summarize the overall performance of the devices tested in this project, and permit the reader/user to see the variation in performance. No endorsement, implied or explicit, is made as to the suitability of any of these devices as to their use for training or as tactical devices.

The NFDDs tested in this project were designed to produce counter-personnel effects, through functional mechanisms that are not intended to produce lethal injury. Less-than-lethal NOISE/FLASH generating devices are often deployable by hand, making their functional delay time critical to user safety and protection. They are intended to produce minimal or no fragmentation or collateral damage, and typically contain mixtures of fast burning propellants and pyrotechnics to produce the desired noise/flash counter-personnel effects. The available manufacturer supplied information accompanying these devices stated that these units are "*pyrotechnic, energetic devices and may cause physical injury or death*." Safety warnings are included as to training and deployment use by trained and authorized personnel only; as such, each prospective user should seek out all relevant component and end product materials safety data sheets (MSDS) before handling, storage, or use of these devices. Shipping, handling, and safe storage of these devices should follow all applicable federal, state, and local regulations and best practices, e.g., the latest revision of DOD 4145.26-M, "Contractor's Safety Manual for Ammunition and Explosives."

The tests and performance characterizations performed in this project were:

Series I:
1. Illuminance and Radiant Flux (FLASH)
2. Acoustic Sound (NOISE)
3. Function Delay (from pulled safety pin to first light)
4. Function Duration (burn time)

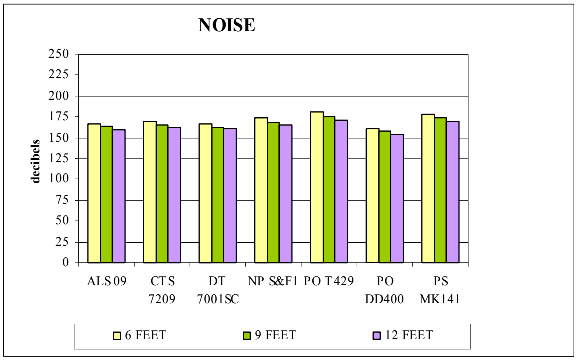
Series II:
1. Fragmentation due to Function

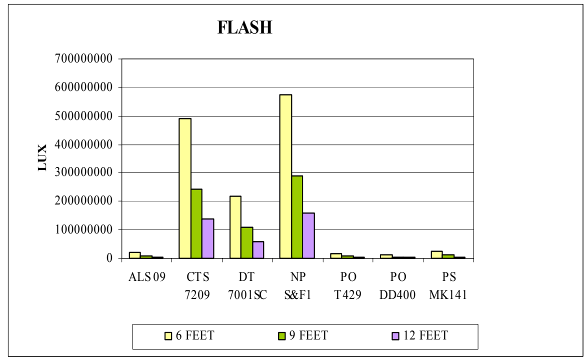
Series III:
1. Collateral Effects (Fire Start, Propulsive Movement, Disruption of Vicinity)

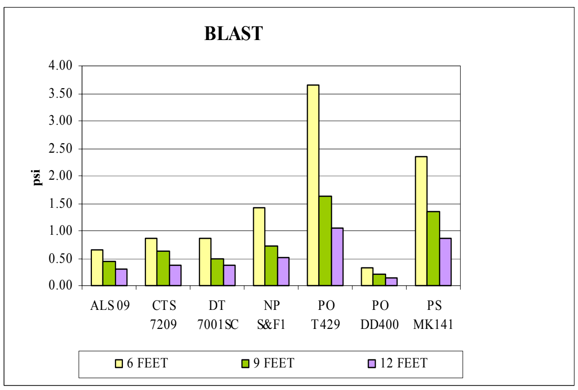
These tests were conducted using eight different NFDDs, from six different manufacturers, provided as Government Furnished Materials (GFM).

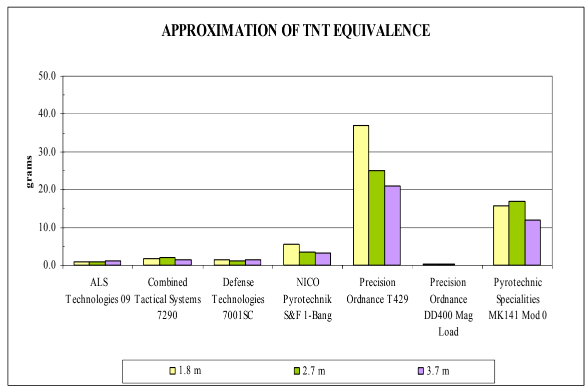
Manufacturer	Model
ALS Technologies	ALS09
Combined Tactical Systems	7290
Defense Technologies	7001SC
Defense Technologies	Omni Blast 100
NICO Pyrotechnik	Sound & Flash 1-Bang
Precision Ordnance	DD400 Mag Load
Precision Ordnance	T429
Pyrotechnic Specialties	MK141 Mod 0

The average peak NOISE/FLASH and BLAST results versus distance for these devices are summarized in the charts below. The approximation of each round's TNT equivalence is also portrayed.

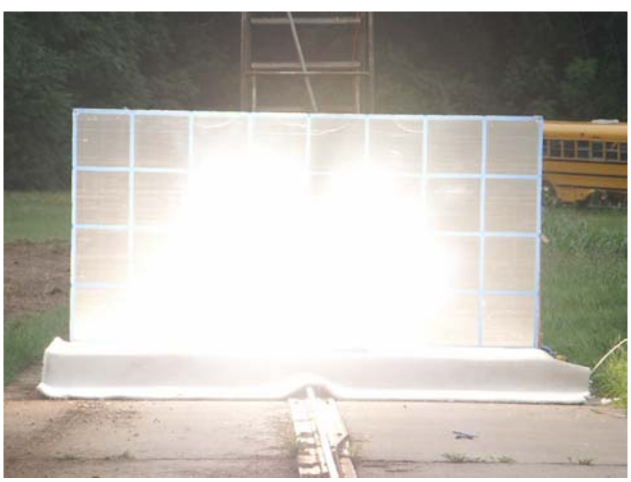








An example of some of the more dramatic collateral effects produced in these tests are shown in the photographs below. Pillows, sofa cushions, and various household objects such as paper, clothing, and carpet were utilized in these tests, to approximate a residential setting. The NFDDs were functioned remotely and allowed to fall freely to the carpeted test surface, similar to how they might be deployed in a real setting.



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1.0 BACKGROUND

E-LABS, Inc. conducted characterization testing of less-than-lethal Noise Flash Diversionary Devices (NFDDs), to quantitatively assess their primary functional performance and subjectively determine collateral effects upon common residential items and materials. This work was accomplished for the Office of Justice Programs (OJP) under the authority of National Institute of Justice (NIJ) Grant 2002-DT-CX-K001, ID Number 065595.

These tests were undertaken to provide consistent, controlled functional measurements for select performance elements of these devices, not as a competitive assessment of brands, models, or types of NFDDs. It was not the intent of the sponsor or E-LABS to identify or define the "best" NFDD from among these samples. Comparative listings of the results are offered merely as information, to summarize the overall performance of the devices in this project, and permit the reader/user to see the variation in performance. *No endorsement, implied or explicit, is made as to the suitability of any of these devices for their use in training or as a tactical device.*

1.1 SCOPE

This report describes the characterization of eight models of NFDD, from six different manufacturers. The tests were conducted under ambient environmental conditions, and were organized into three separate series of tests. The first series of tests characterized each device's primary diversionary (NOISE/FLASH) performance and safety related functions; the second series evaluated residual fragmentation using a simple witness arena; while the third series subjectively assessed collateral fire-start and propulsive movement effects of NFDDs when functioned in close proximity to common household materials. The details and measurement units of each series are summarized thus:

CHARACTERIZATION TESTING:

Series I:

1. Illuminance and Radiant Flux - FLASH
   a) Peak level (LUX) and total light energy (Joules) at varied ranges
2. Acoustic Sound - NOISE
   b) Blast overpressure in air (bar)
   c) Peak sound (decibels)
3. Function Delay – SAFETY DELAY
   d) Function lever ("spoon") release to first light (seconds)
4. Function Duration- BURN TIME
   a) Emitted light duration (seconds)
5. Pre and Post test assembly weights (oz)

Series II:

Fragmentation
   b) Paper and foamboard witness panels (number of fragment impacts)

Series III:

Collateral Effects
   a) Fire - defined as visible flame(s) (Yes / No)
   b) NFDD propulsive movement (nominal travel)
   c) Disruption of test object(s) (Yes / No)

No attempt to infer or quantify any performance has been made with respect to an NFDD's less-than lethal incapacitation or injury producing ability, its effectiveness against humans, or other biologicals, or for any real world application or situation. The laboratory generated data describes the measured functional characteristics of the devices when functioned in a controlled situation only. No endorsement, implied or explicit, is made as to the suitability of any of these devices for their use.

2.0 DESCRIPTION

2.1 TEST ARTICLES

The NFDDs tested in this project were designed to produce counter-personnel effects, through functional mechanisms that are not intended to produce lethal injury. Counter-personnel effects are often described as "neutralizing" or "disorienting" to hostile individuals and crowds. Two general types of mechanisms are used to produce an NFDD's desired counter-personnel effects: NOISE, which is a loud audible sound pulse generated by blast overpressure, and FLASH, which is a rapid generation of visible light. Less-than-lethal NOISE/FLASH generating devices are frequently deployable by hand, making their functional delay time critical to user safety and protection. They are intended to produce minimal or no fragmentation or collateral damage, and typically contain chemically energetic mixtures of fast burning propellants and pyrotechnics to produce the noise/flash mechanisms.

The manufacturer information accompanying these devices stated, in general, that they are "pyrotechnic, energetic devices, and may cause physical injury or death." Safety warnings are included as to training and deployment use by trained and authorized personnel only; as such, each prospective user should seek out all relevant energetic component and end product materials safety data sheets (MSDS) and the performance specifications before purchase or use of these devices. Shipping, handling, and storage of these devices should follow all applicable federal, state, and local regulations and best practices, e.g., the latest revision of DOD 4145.26-M, "Contractor's Safety Manual for Ammunition and Explosives" [sec. 4, item 1]. Figure 1 provides an example of a composite image time sequence of an NFDD characterization test.

Figure 1. Digital SLR Camera Frame Sequence (Partial) of NFDD Fireball Growth and Decay

2.1.1 NFDD Test Devices

Table 1. Test Device Inventory - Final

Manufacturer	Model	Quantity
ALS Technologies	ALS09	28
Combined Tactical Systems	7290	34
Defense Technologies	7001SC	46
Defense Technologies	Omni Blast 100	34
NICO Pyrotechnik	Sound & Flash 1-Bang	34
Precision Ordnance	DD400 Mag Load	28
Precision Ordnance	T429	28
Pyrotechnic Specialties	MK141 Mod 0	27

Several of the supplied NFDDs were comprised of reusable body components and expendable cores. For those NFDDs which required assembly, a photograph of the components in an exploded assembly format was taken. Examples of these pictures are provided in the respective NFDD appendix summaries.

2.2 PERFORMANCE CHARACTERIZATION

Characterization tests in Series I and II measured illuminance and radiant flux, blast overpressure and sound, functional delay and burn duration of the device, and fragmentation. Series III tests demonstrated the NFDD's collateral damage potential for fire-start and device movement, caused by hot and propulsive gas escaping/venting from the body or casing. Test article weights, dimensions, and other relevant measures were recorded for pre test and post test conditions.

2.2.1 **Series I: Light (FLASH) Characterization**

Illuminance is a measure of the visible flux density, or intensity, of light (visible radiation) covering a specified area at a specified distance, weighted to the visible light spectrum that the human eye sees [sec. 4, item 2]. It is measured directly in watts per square meter and expressed as units of LUX, which are equivalent to one Lumen per square meter. The comparable English areal unit is the foot candle (ft-candle) which is one Lumen per square foot. Figure 2 depicts this measurement, and the equivalent units of measure.

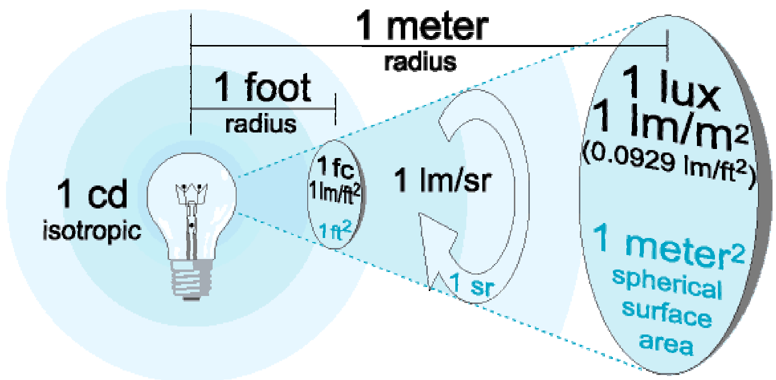


Figure 2. Illuminance

The intensity of light without respect to areal coverage is defined as radiant flux; it is also weighted to take into account the variable response of the human eye as a function of the wavelength of light emitted by the source [sec 4, item 2]. Radiant flux is measured directly in watts per square meter-sec and expressed in units of Joules (one watt = one Joule). Radiant flux is not an expression of light density (areal coverage) as illuminance is, but an expression of radiant energy.

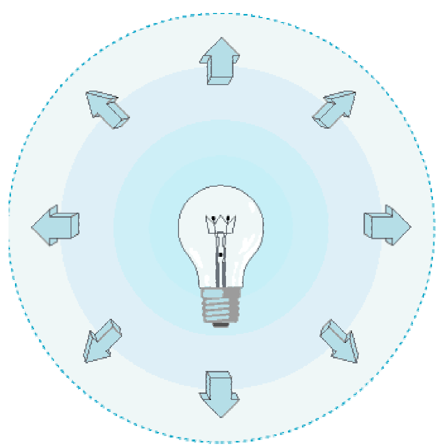


Figure 3. Radiant Flux Output

Direct measurement of the subject NFDD's illuminance and radiant flux was accomplished through use of flash detectors capable of recording both duration and peak in watts per square meter (W/m^2). Measurements were initially taken at standoff distances of three, five, and ten feet with the flash sensor/detectors aligned normal (90-degrees) to the center of the vertically oriented NFDD. It was quickly discovered that this set of ranges was too close to permit consistently accurate measure of the output light as desired, due to the size of the fireball and composite blast (hot gas and micro particles) zone produced, which enveloped the nearest detector and produced inconsistent data. The stand-off distances were then increased to six, nine, and twelve feet for all subsequent tests.

The flash sensor/detectors were arrayed on 15-degree, 30-degree, and 340-degree radials, adjacent to the pressure recording devices. Figure 4 presents a representative set of twenty light versus time measurements in W/m^2. The peak values and time integral for each test were identified and converted to LUX and Joules respectively, to express illuminance and radiant flux. These values are reported in each NFDDs respective appendix, and the arithmetic mean (average) values for each NFDD's 20 test set are presented in the summary data in Table 3 (sec 3.1).

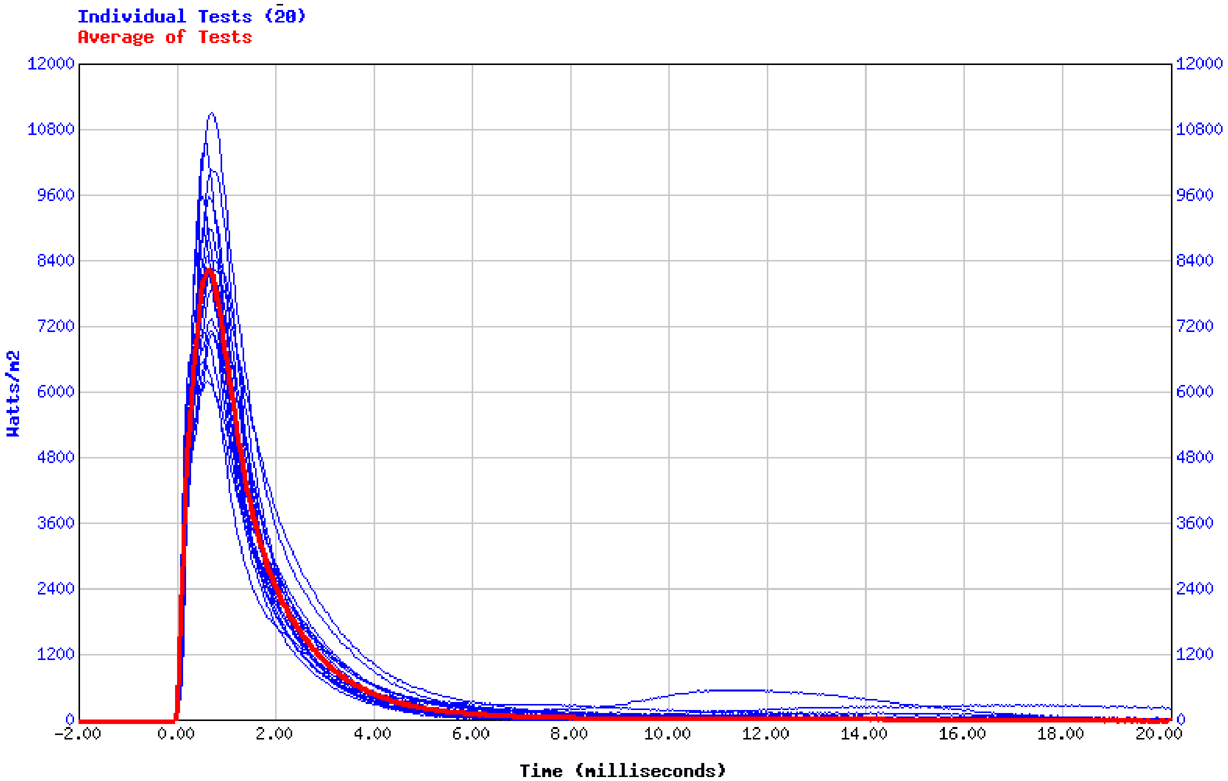


Figure 4. Example NFDD Peak Light and Decay at 6-feet – 20 Test Overlays

2.2.2 Series I: Sound (NOISE) Characterization

One of the concerns associated with the use of pyrotechnic or explosive based devices is the high level of sound generated by them, with respect to hearing impairment or damage. One example of assessing this characteristic is the determination of transient peak levels. Industrial and military standards exist for evaluating the measured impulse noise of a weapon or, in this case, an NFDD. The Department of Defense has established parameters for evaluating the need for hearing protection in personnel occupied areas, to specifically protect from impulse (transient) sound waves [sec. 4, item 2]. Those standard levels are reproduced here to provide a context for assessing the subject NFDD noise levels. All of the devices tested exceeded the 140 decibel threshold (W) requirement for use of hearing protection.

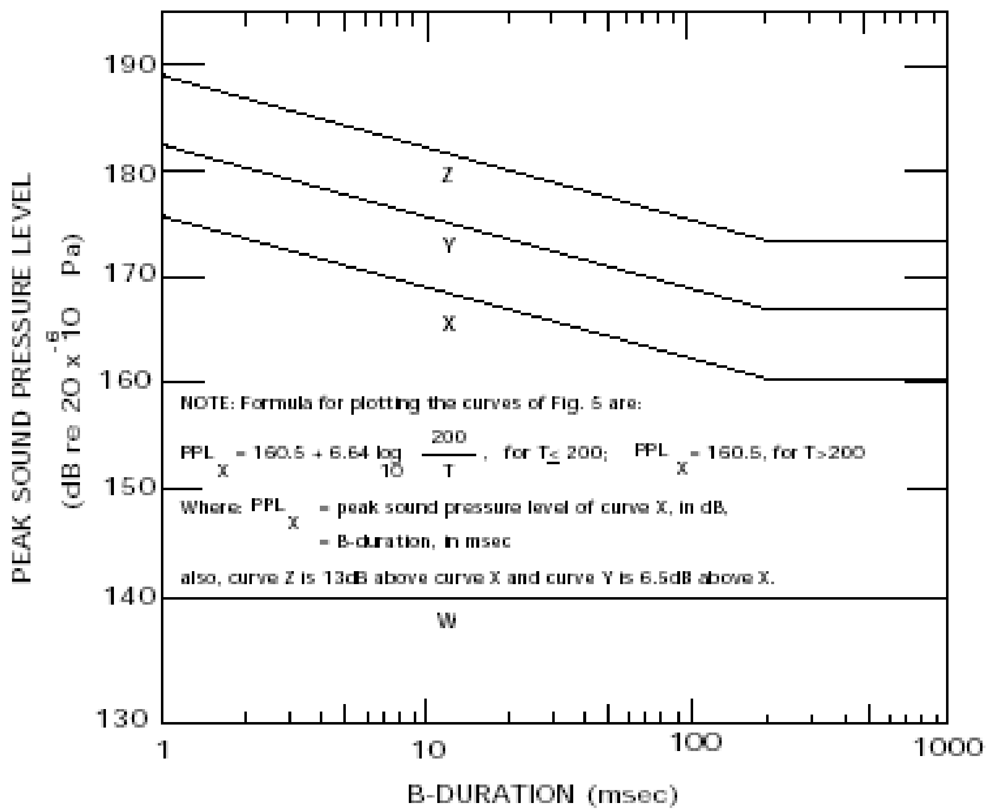


Figure 5. Peak Sound Levels and B-Duration Limits for Impulse Noise
Note - Use of Levels in Excess of Limit W Requires Hearing Protection

The sound (NOISE) of the NFDDs was measured using piezo-electric pressure transducers to directly measure the generated shock pressure in air. Those results were converted into decibel (dB) sound measurements. The overpressure traces in figure 6 demonstrate the classic behavior of an explosive shock in air, with ascension to a rapid peak (positive pressure), followed by a slower degradation back to baseline, and a subsequent negative pressure phase, followed by a secondary reflection from the ground. The maximum impulse (transient) sound level was calculated using the peak value of the initial positive pressure segment. The pressure transducers were oriented to measure the normal, or incident (side-on) pressure wave, and were placed along the same radials as the flash sensor/detectors, and at the same measurement distances (fig. 9). The actual measurements were recorded as pounds per square inch (psi), and converted to SI units (bar) for reporting.

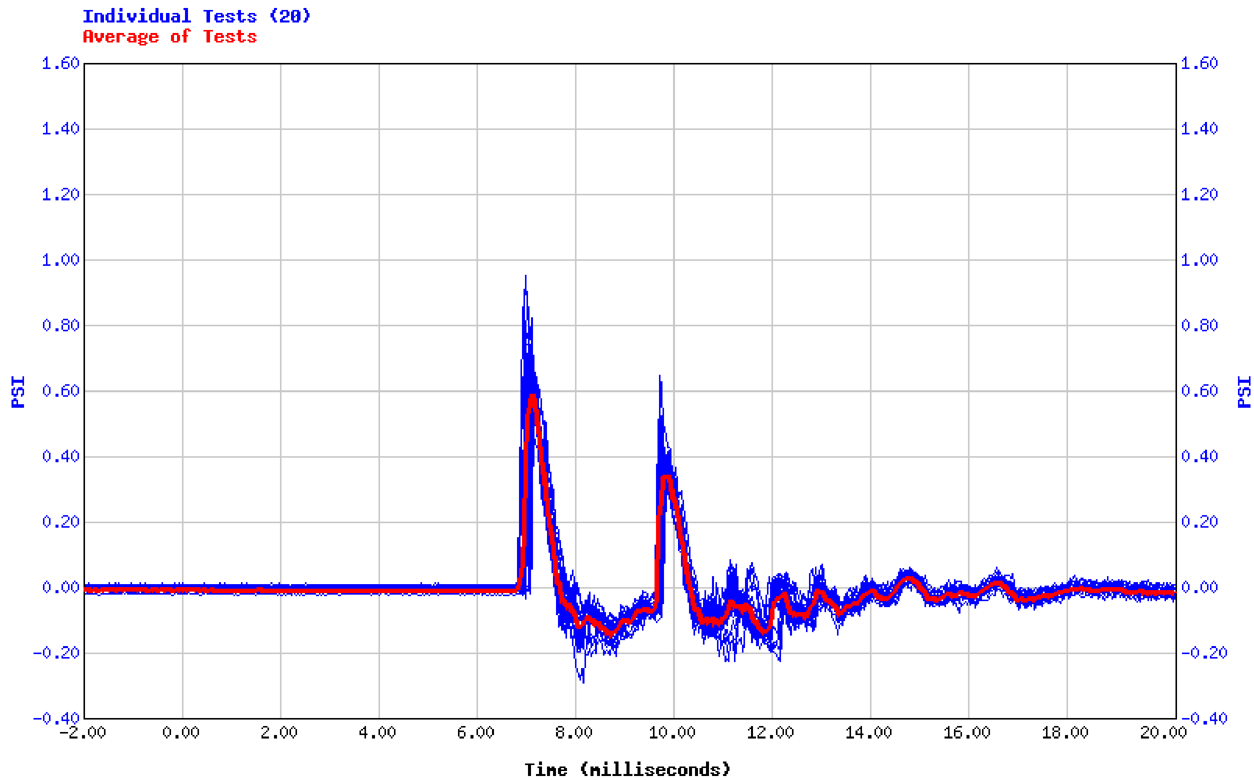


Figure 6. Sample Overpressure Peak and Decay at 9-feet – 20 Test Overlays

Note: Secondary peak is reflected

2.2.2.1 *Functional Delay and Duration*

The functional delay safety measurement of the NFDDs in Series I was obtained by recording the elapsed time from remotely pulling the safety pin and releasing the "spoon" until the device began to function, i.e., the first light measured by the flash detectors. The devices were tested in the vertical orientation with respect to the ground surface for all light, sound, and functional performance. The duration of the FLASH was obtained from the light readings taken by the flash detectors. All measurements were taken with time resolutions less than a millisecond, and reported as seconds to provide a more practical context for the user audience.

2.2.2.2 *TNT Equivalence*

Portraying the overpressure yield of an NFDD against a common, conventional explosive material may give the user of the device a simpler means of assessing the nominal force of the devices, assuming they have some familiarity with energetic materials. By using the measured peak positive pressure of a pyrotechnic or explosive device, in this case, an NFDD, its TNT weight equivalence can be calculated. According to Kinney and Graham [sec. 4, item 4], most types of blast pressure (yield) can be related to an equivalent amount of TNT, by using measured peak pressure and an empirically derived scaling equation, $Z = R/W^{1/3}$, where Z is scaled distance, R is real distance, and $W^{1/3}$ is the TNT explosive yield. TNT has been exhaustively characterized for overpressure in incremental stand-off distances, and by using that reference data and the scaling equation, overpressure of different materials and devices can be related to a TNT equivalence. Approximate TNT weight equivalents for each of the average NFDD blast overpressures have been calculated using this approach, and appear in the summary results (sec. 3.2).

2.2.3 **Series II: Fragmentation**

Fragmentation of the NFDD was measured using a surrounding boundary of lightweight witness materials (paper covered foamboard), that registered the impact of fragments generated by the functioning of the NFDD (fig. 11 and 12). The standoff distance to the radially positioned witness panels was six feet. The number of fragment impacts sized greater than 0.25-inch were counted, and segregated by perforation through foamboard or paper. The NFDD devices were fired in the vertical orientation with respect to the ground surface.

Figure 7. Set-Up of Fragmentation Arena – Fixturing and Witness Panels

2.2.4 **Series III: Collateral Effects**

Subjective fire-start capability was tested using potentially flammable objects placed within the expected functional region of the NFDD, at various distances less than 6.0 feet (fig. 13). These subjects were representative household objects: clothing, furniture cushions, pillows, paper products, and carpeting similar to what might be found in a residential space. During the fire-start tests, video camera and digital SLR photographic records (facing view) of the test set-up were taken. Flame break-out, NFDD propulsive movement, and test object disruption were subjectively determined using these records. Scalar markers on a background foamboard witness panel (surrogate wall) were used to approximate the nominal amount of propulsive travel generated by the functioning of the NFDD.

Each NFDD was oriented horizontally with respect to the ground surface; to conduct the test, the safety pin was remotely pulled and the NFDD allowed to freely fall onto the object or carpet covered test floor. The NFDD was free to bounce or roll as dictated by the fall and test object. In some of the pillow and cushion tests, the NFDD came to rest between the object and the witness background, such as could occur in a room, causing some confinement (enhancement of blast effects) and producing severe damage to the witness board. Section 3.3 contains a summary of the results of these tests.

Figure 8. Witness Panel Damage Due To Confinement of NFDD between Test Object and Panel

2.3 TEST RANGE LAYOUTS

Sketches of the test layouts showing the positioning and distances of the test elements are shown for each of the three test series. Accompanying photographs further illustrate the set-up of these tests.

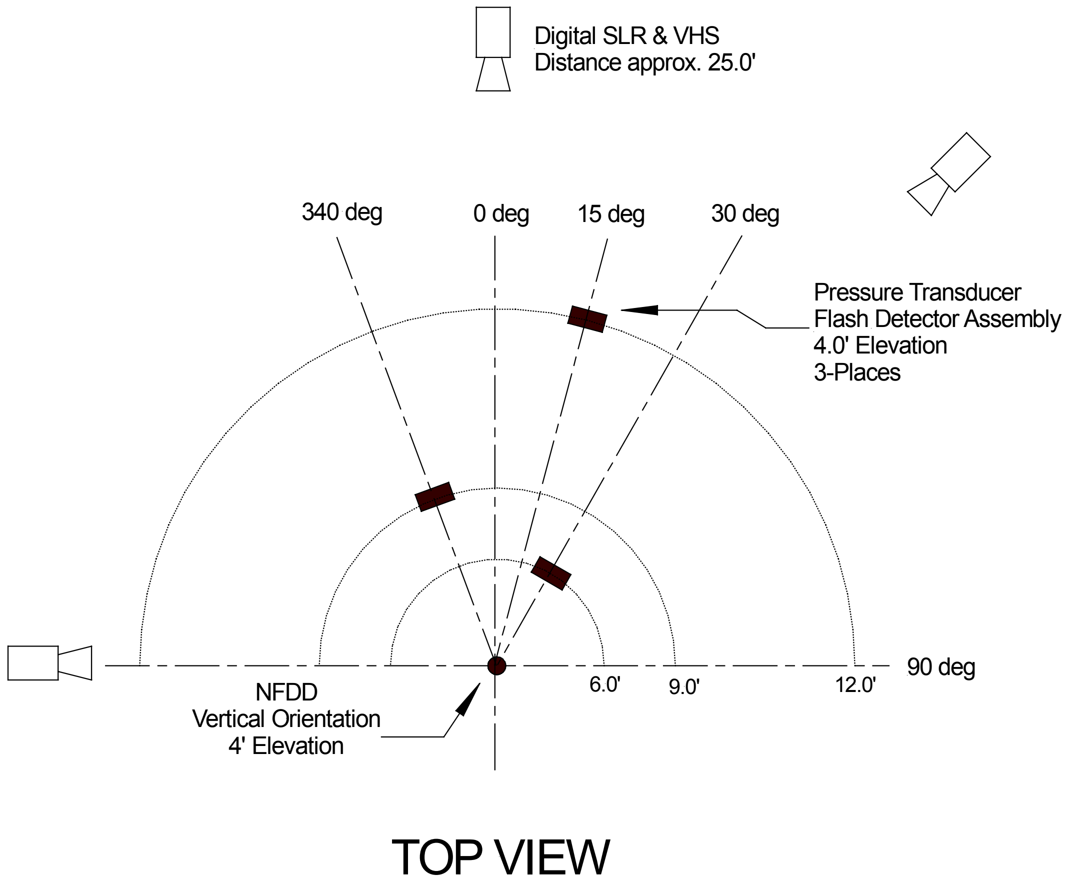


Figure 9. Light and Sound Test Range Layout

Figure 10. Test Stand, Remote Firing Fixture, and Example Set-Up

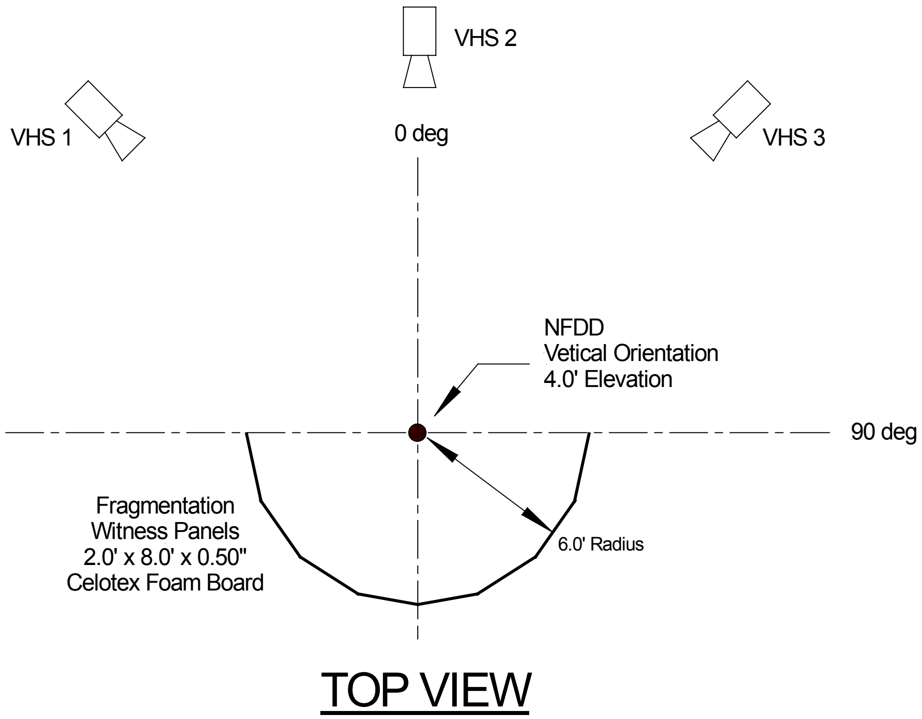


Figure 11. Fragmentation Test Range Layout

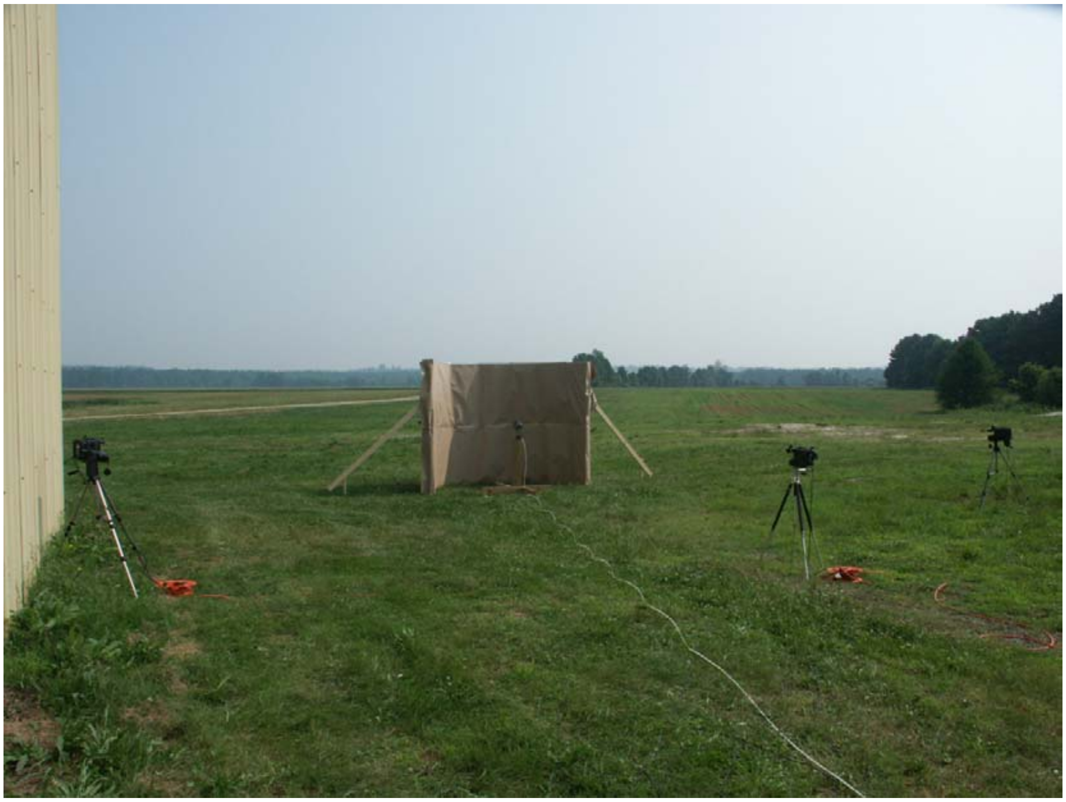


Figure 12. Example Fragmentation Arena – Pre-Test

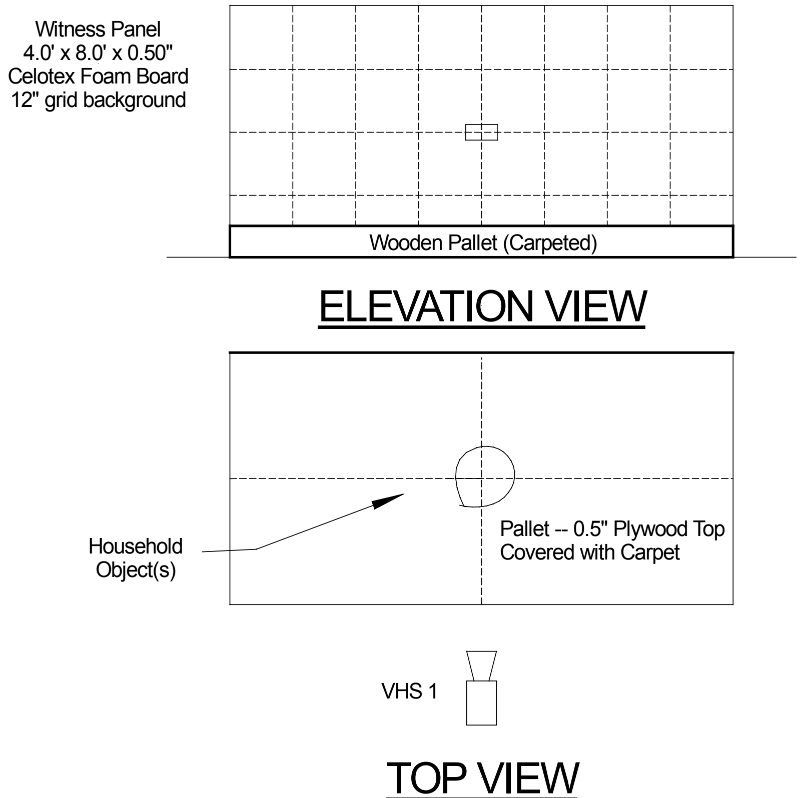


Figure 13. Collateral Effects Test Range Layout

Figure 14. Example Collateral Effects – Partial Pillow Test Sequence (Digital SLR)

2.4 FINAL TEST MATRIX

This matrix summarizes the type and distribution of the 199 tests conducted using the eight models of NFDDs provided for this project. All of the devices were expendable Government Furnished Material (GFM).

Table 2. Final Test Matrix

			Tests Conducted		
Manufacturer	**Model**	**Device Inventory**	**Light & Sound**	**Fragmentation**	**Collateral Effects**
ALS Technologies	ALS09	28	20	3	3
Combined Tactical Systems	7290	34	20	3	3
Defense Technologies	7001SC	46	20	3	3
Defense Technologies	Omni Blast 100	34	20	3	3
NICO Pyrotechnik	Sound & Flash 1	34	20	3	3
Precision Ordnance	DD400 Mag Load	28	11*	3	3
Precision Ordnance	T429	28	20	3	3
Pyrotechnic Specialties	MK141 Mod 0	27	20	3	3
	Total:	**259**	**151**	**24**	**24**

* 20 tests were conducted; nine have been excluded due to measurement equipment malfunction.

2.5 INSTRUMENTATION

A custom high-speed data acquisition system (DAS) controlled each test. The system consists of 16-channels of analog to digital recording, capable of sampling rates of 100,000 points per second. The DAS uses a UNIX based operating system with custom test and analysis software. The DAS remotely controlled all tests, from initiation (pulling the NFDD pin) to sequencing the cameras and recording the light and pressure detector signals.

2.5.1 Test Equipment

Type:	Model:	Manufacturer:
1. Flash Detector	PMA2135	Solar Light Co.
2. Pressure Transducer	119A11	PCB, Inc.
3. Digital Acquisition System (DAS)	Custom	RKB Enterprises
4. Personal Computer	Inspiron 7800	Dell

3.0 SUMMARY RESULTS

The results presented in this section represent summaries of the entire set of tests conducted for each NFDD from each of the three series. The arithmetic mean values from the individual test set (20 tests) are listed for each of the primary characteristics measured. Summary charts are also provided illustrating the average values presented in the data tables.

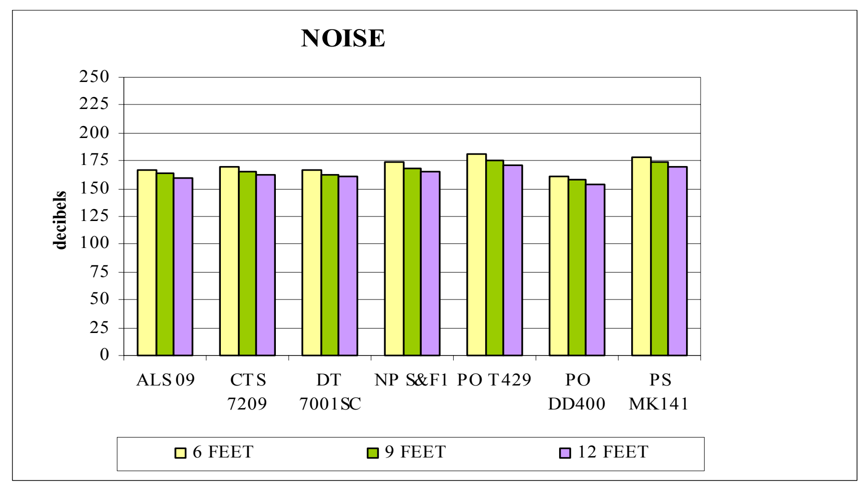
Full details for each individual test set by test series for each of the eight NFDDs are presented in their corresponding appendix. Other details such as packaging descriptions, weights, and select photographs of the NFDDs and their tests are also included in the appendices.

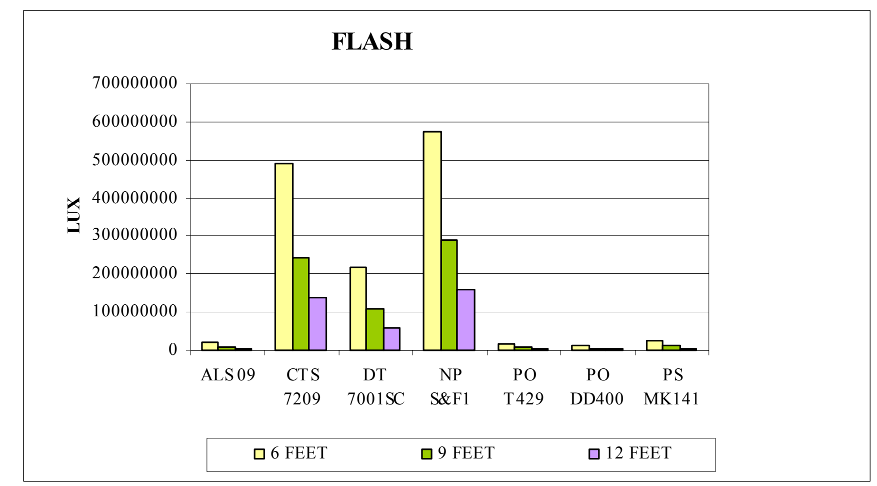
3.1 FUNCTIONAL CHARACTERISTICS

Table 3. NFDD Function, Sound, and Light Summary – Vertical Firing Orientation

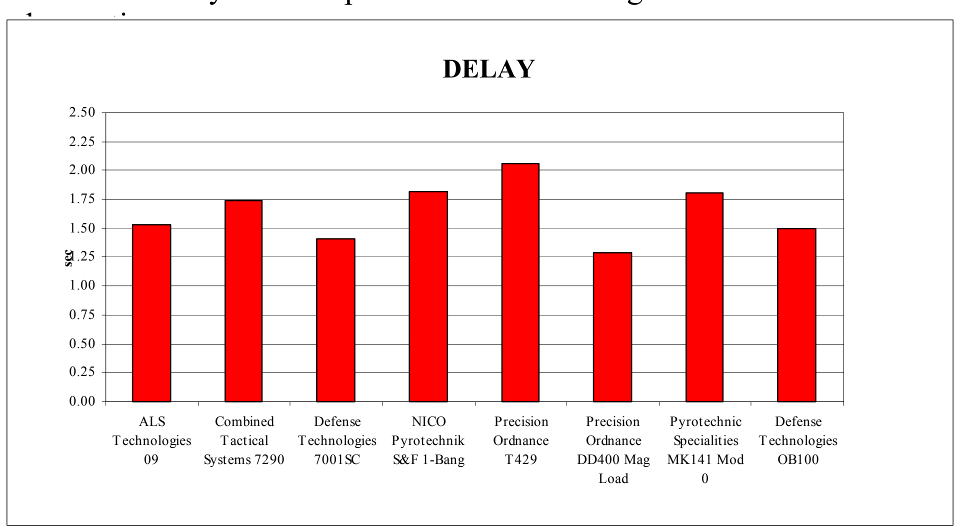
NFDD	USE/BODY	VENTING METHOD	AVERAGE FUNCTION DELAY sec.	AVERAGE FUNCTION BURN sec.	AVERAGE PEAK VALUE 6 FEET BLAST bar	6 FEET NOISE db	6 FEET FLASH LUX	6 FEET FLASH ENERGY J	9 FEET BLAST bar	9 FEET NOISE db	9 FEET FLASH LUX	9 FEET FLASH ENERGY J	12 FEET BLAST bar	12 FEET NOISE db	12 FEET FLASH LUX	12 FEET FLASH ENERGY J
ALS Technologies 09	Multiple / Steel	Axial-Top/Bottom	1.53	0.0026	0.046	167	19,999,063	0.4	0.030	164	8,534,524	0.2	0.021	160	3,591,085	0.1
Combined Tactical Systems 7290	Single / Steel	Axial-Top/Bottom	1.74	0.0120	0.060	169	490,129,734	48.1	0.043	165	244,200,090	24.9	0.026	162	140,308,270	14.2
Defense Technologies 7001SC	Multiple / Steel	Axial-Top/Bottom	1.41	0.0099	0.059	167	219,219,501	15.0	0.034	163	106,904,697	7.5	0.026	160	60,512,851	4.3
NICO Pyrotechnik S&F 1-Bang	Single / Steel	Radial-Ejects Hole Plugs	1.82	0.0034	0.097	174	573,776,744	12.5	0.050	168	290,215,999	6.4	0.036	165	158,219,856	3.4
Precision Ordnance T429	Single / Cardboard	Axial-Ejects Bottom Section	2.06	0.0069	0.252	181	14,840,255	0.6	0.112	175	7,634,092	0.3	0.072	171	4,508,879	0.2
Precision Ordnance DD400 Mag Load	Multiple / Aluminum	Axial-Top/Bottom	1.29	0.0045	0.023	161	10,923,176	0.3	0.015	157	4,876,204	0.1	0.010	154	2,763,480	0.1
Pyrotechnic Specialties MK141 Mod 0	Single / Alum Foil	Radial/Consumable	1.80	0.0090	0.162	178	27,196,657	1.4	0.094	173	12,073,743	0.5	0.059	169	6,224,204	0.3
					3 FEET				5 FEET				10 FEET			
Defense Technologies OB100	Single / Plastic	Axial-Rupture	1.50	0.0210	0.385	186	25,858,199	4.2	0.201	180	9,864,306	1.4	0.070	171	1,642,588	0.3

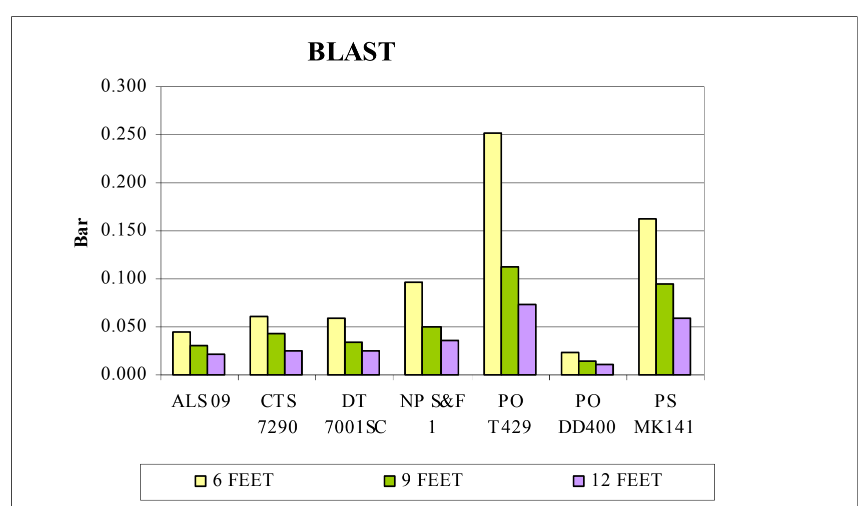
NFDD	PRE TEST ASSEMBLY oz	POST TEST ASSEMBLY oz
ALS Technologies 09	21.58	20.16
Combined Tactical Systems 7290	23.00	20.90
Defense Technologies 7001SC	25.08	23.17
Defense Technologies OB100	9.22	7.68
NICO Pyrotechnik S&F 1-Bang	10.09	7.90
Precision Ordnance T429	6.94	2.97
Precision Ordnance DD400 Mag Load	9.12	7.90
Pyrotechnic Specialties MK141 Mod 0	3.62	0.89





Functional delay is from spoon release to first-light





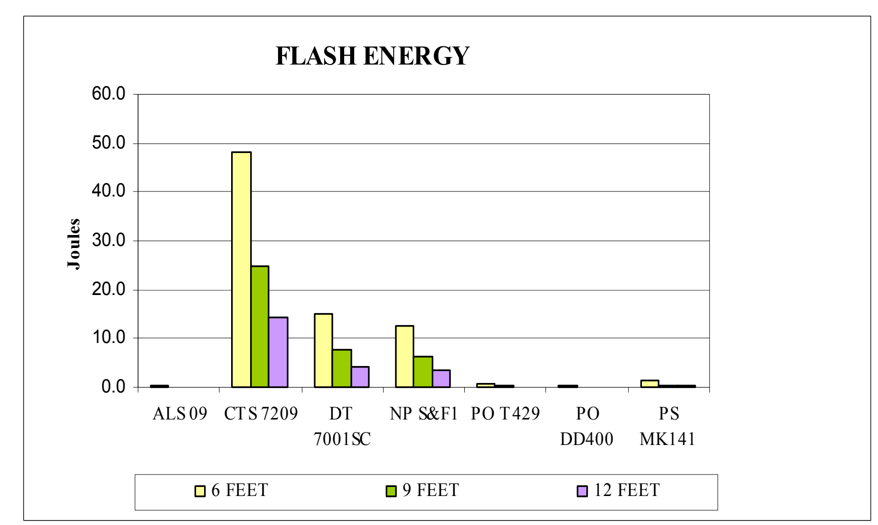
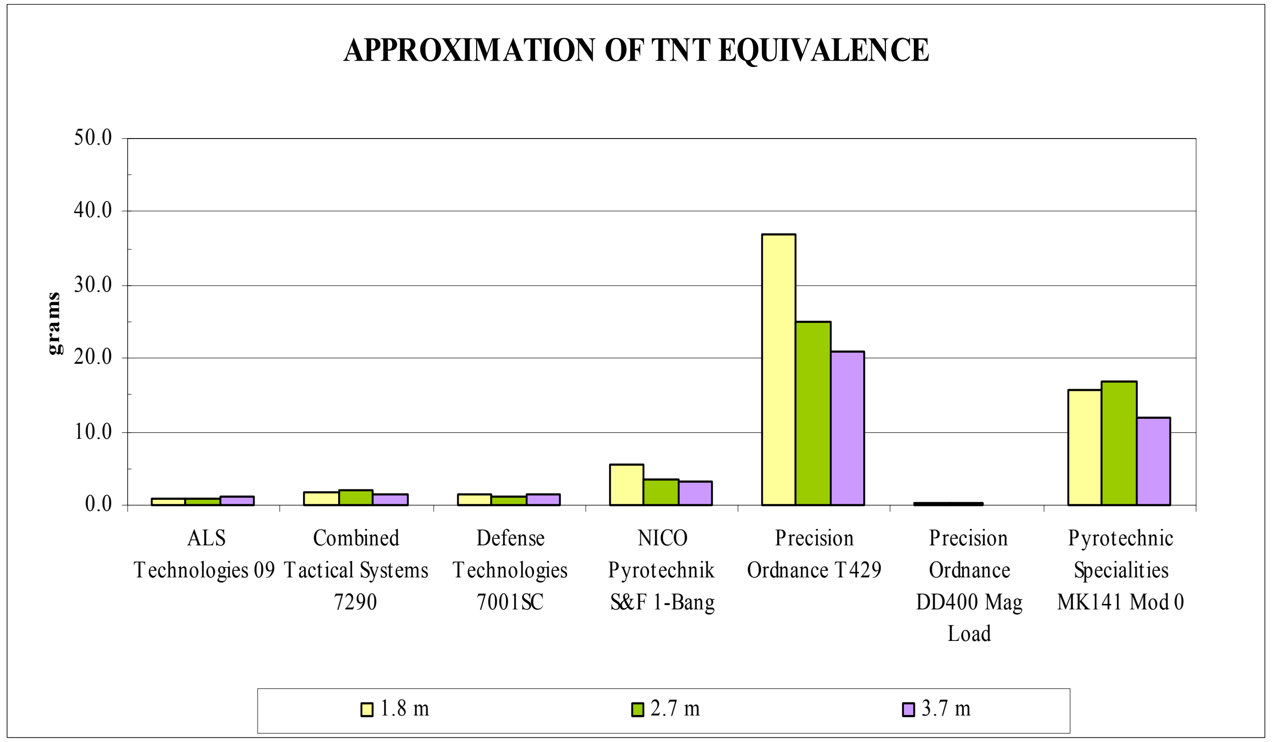


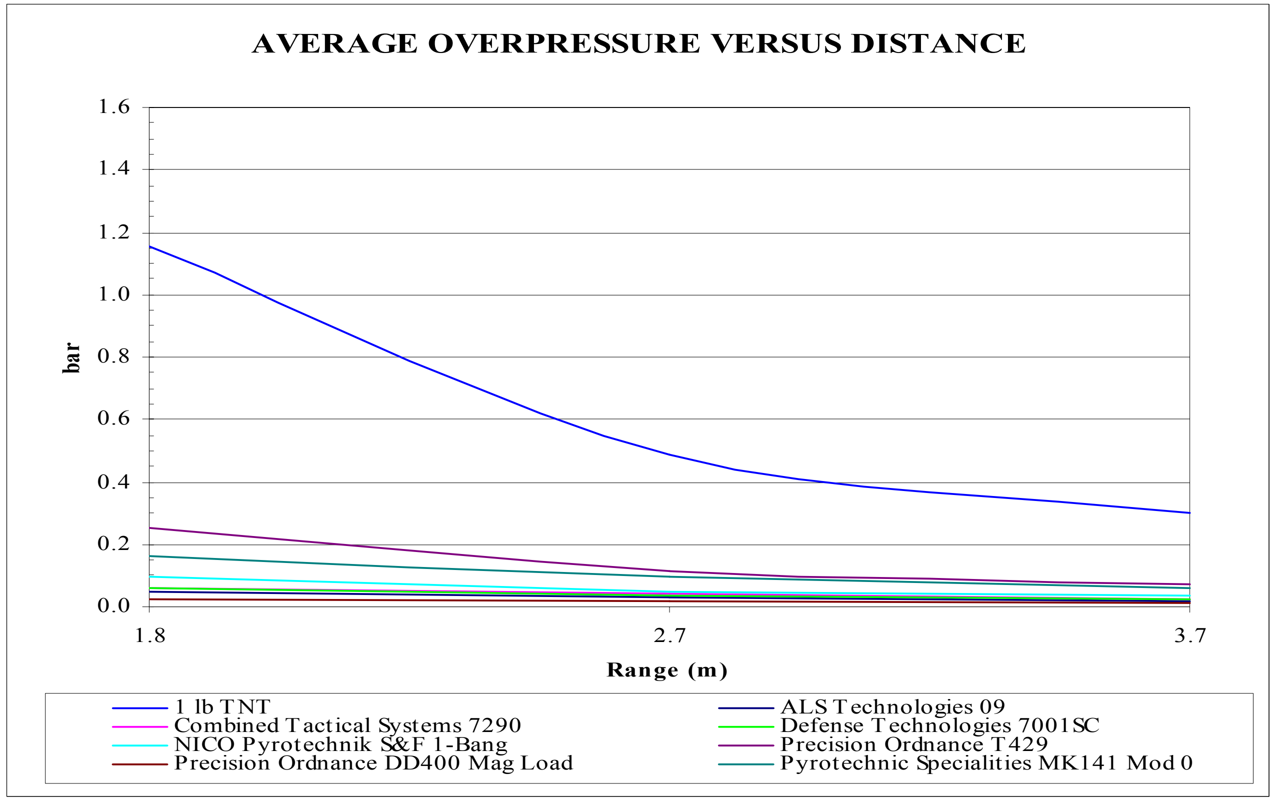
Table 4. TNT Equivalence Based Upon Average Measured Overpressure

NFDD	Avg. Pressure psi	Avg. Pressure bar	R ft	R m	Z (m)	W 1/3 kg	TNT Equivalence oz	TNT Equivalence g
1 lb TNT	**16.758**	**1.155**	6.0	1.8	1.8	0.454	**16.000**	**454.0**
ALS Technologies 09	0.66	0.046			20.5	0.001	0.027	0.766
Combined Tactical Systems 7290	0.87	0.060			15.5	0.002	0.064	1.816
Defense Technologies 7001SC	0.85	0.059			16.0	0.001	0.053	1.496
NICO Pyrotechnik S&F 1-Bang	1.41	0.097			10.4	0.005	0.192	5.448
Precision Ordnance T429	3.65	0.252			5.6	0.037	1.299	36.835
Precision Ordnance DD400 Mag Load	0.33	0.023			34.0	0.000	0.005	0.156
Pyrotechnic Specialties MK141 Mod 0	2.35	0.162			7.4	0.016	0.556	15.754
1 lb TNT	**7.109**	**0.490**	9.0	2.7	2.7	0.454	**16.000**	**454.0**
ALS Technologies 09	0.44	0.030			29.0	0.001	0.030	0.848
Combined Tactical Systems 7290	0.63	0.043			22.0	0.002	0.069	1.942
Defense Technologies 7001SC	0.50	0.034			26.5	0.001	0.042	1.177
NICO Pyrotechnik S&F 1-Bang	0.72	0.050			18.5	0.004	0.125	3.547
Precision Ordnance T429	1.62	0.112			9.4	0.025	0.878	24.903
Precision Ordnance DD400 Mag Load	0.22	0.015			42.0	0.000	0.010	0.279
Pyrotechnic Specialties MK141 Mod 0	1.36	0.094			10.7	0.017	0.595	16.884
1 lb TNT	**4.331**	**0.299**	12.0	3.7	3.7	0.454	**16.000**	**454.0**
ALS Technologies 09	0.30	0.021			36.5	0.001	0.037	1.051
Combined Tactical Systems 7290	0.37	0.026			32.0	0.001	0.053	1.496
Defense Technologies 7001SC	0.37	0.026			32.0	0.001	0.053	1.496
NICO Pyrotechnik S&F 1-Bang	0.52	0.036			25.5	0.003	0.111	3.138
Precision Ordnance T429	1.05	0.072			13.3	0.021	0.735	20.840
Precision Ordnance DD400 Mag Load	0.15	0.010			73.0	0.000	0.004	0.126
Pyrotechnic Specialties MK141 Mod 0	0.86	0.059			16.0	0.012	0.422	11.970

1 lb TNT reference pressures from Kinney/Graham tables for respective Z

Z scaled distances from Kinney/Graham tables for respective measured pressure

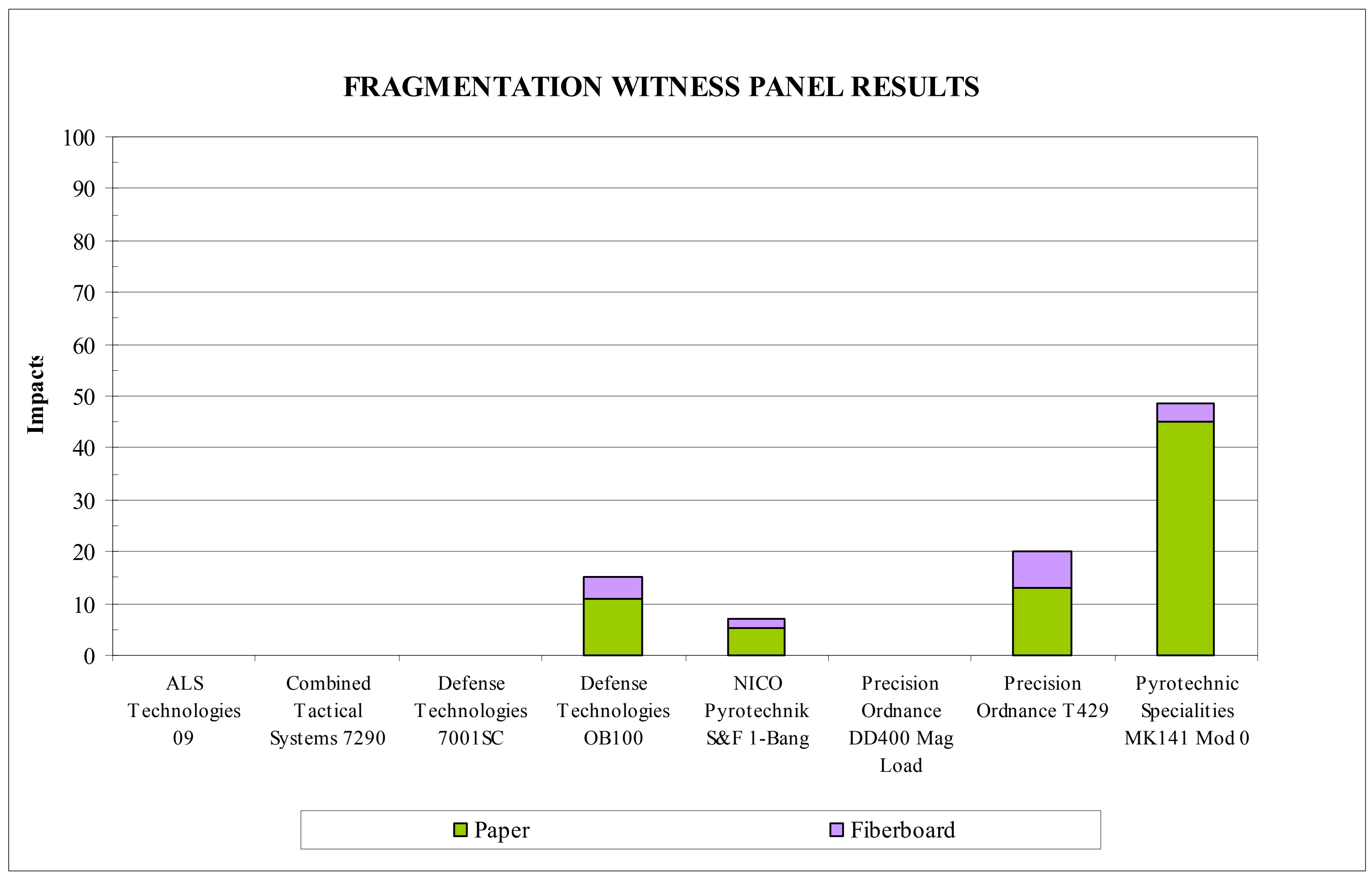




3.2 FRAGMENTATION

Table 5. NFDD Fragmentation Summary

NFDD	USE/BODY	VENTING METHOD	AVERAGE WEIGHT PRE oz	AVERAGE WEIGHT POST oz	WITNESS PANEL RESULTS AVG. IMPACTS	AVG. PERFORATIONS PAPER	AVG. PERFORATIONS FOAMBOARD
ALS Technologies 09	Multiple / Steel	Axial-Top/Bottom	2.57	1.73	0	0	0
Combined Tactical Systems 7290	Single / Steel	Axial-Top/Bottom	23.05	21.75	0	0	0
Defense Technologies 7001SC	Multiple / Steel	Axial-Top/Bottom	4.85	3.50	0	0	0
Defense Technologies OB100	Single / Plastic	Axial-Rupture	9.30	8.26	15	11	4
NICO Pyrotechnik S&F 1-Bang	Single / Steel	Radial-Ejects Hole Plugs	10.08	8.87	7	5	2
Precision Ordnance DD400 Mag Load	Multiple / Aluminum	Axial-Top/Bottom	2.55	1.80	0	0	0
Precision Ordnance T429	Single / Cardboard	Axial-Ejects Bottom Section	7.01	4.02	20	13	7
Pyrotechnic Specialties MK141 Mod 0	Single / Alum Foil	Radial/Consumable	3.60	0.88	49	45	4



3.3 COLLATERAL

Table 6. NFDD Collateral Effects Summary

NFDD	Fire Start by Test			Propulsion of NFDD by Test			Disruption of Objects by Test		
	Pillow	Cushion	Objects	Pillow	Cushion	Objects	Pillow	Cushion	Objects
ALS Technologies 09	No	No	No	< 12"	< 12"	No	No	No	Yes
Combined Tactical Systems 7290	Yes	No	Yes	> 12"	< 12"	No	No	No	Yes
Defense Technologies 7001SC	No	No	No	< 12"	No	No	Yes	No	Yes
Defense Technologies OB100	No	Yes	No	No	No	No	Yes	No	Yes
NICO Pyrotechnik S&F 1-Bang	No	No	No	< 12"	No	> 18"	Yes	Yes	Yes
Precision Ordnance DD400 Mag Load	No	No	No	12"	> 48"	> 48"	Yes	Yes	Yes
Precision Ordnance T429	No	No	No	No	No	No	Yes	No	No
Pyrotechnic Specialties MK141 Mod 0	No	No	No	36"	> 24"	< 12"	No	Yes	Yes

Fire start determined by presence of open flame after functioning	Distance estimated using scalar grid on background	Disruption determined by noting any movement of object(s) from origin

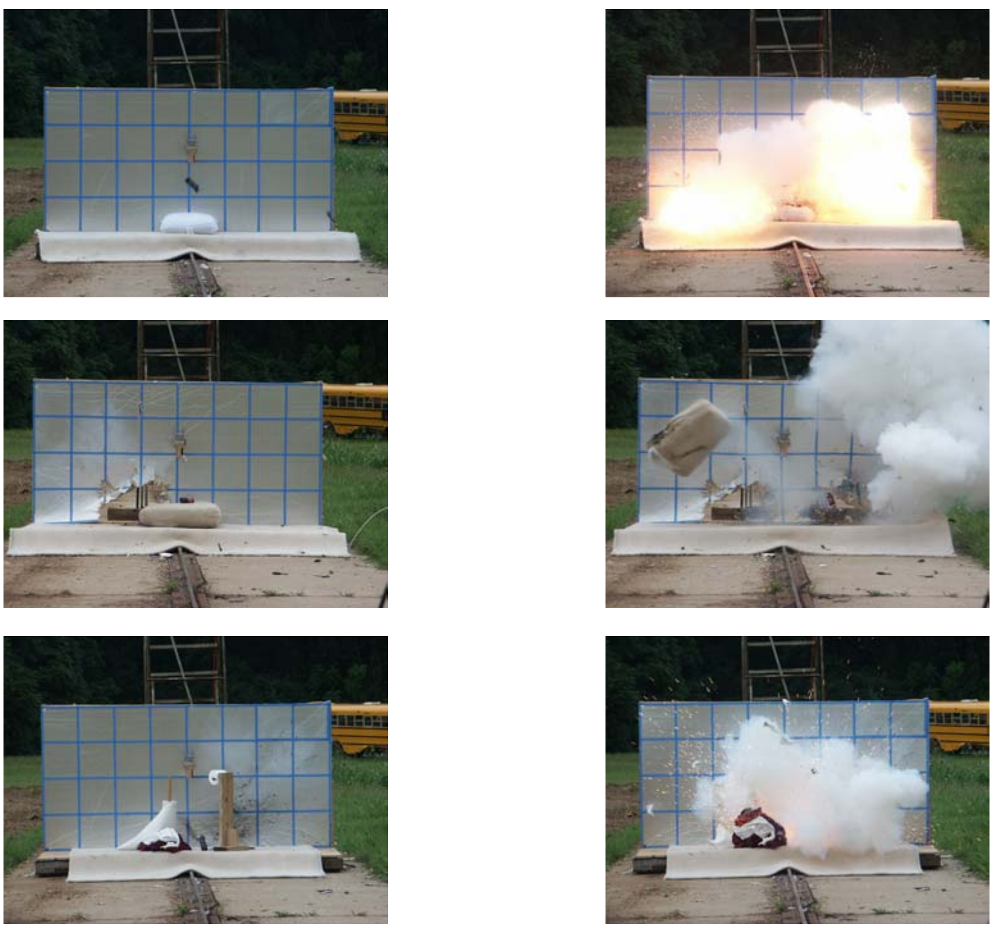


Figure 15. Example Collateral Effects Tests – Showing NFDD Free Fall and Function

4.0 REFERENCES

1. DOD 4145.26-M. "Contractor's Safety Manual for Ammunition and Explosives:. March 1986.

2. DOD MIL-STD-1474D. "Department of Defense Design Criteria Standard Noise Limits". Requirement 4: Impulse Noise in Personnel-Occupied Areas. February 1997.

3. Ryer, Alex. "Light Measurement Handbook." International Light, Internet Source, 1997.

4. Kinney, G. F., Graham, Kenneth J. "Explosive Shocks in Air," Second Edition. Springer-Verlag, New York, 1985.

APPENDIX A

ALS Technologies
ALS09

APPENDIX B

Combined Tactical Systems
7290

APPENDIX C

Defense Technologies
7001SC

APPENDIX D

Defense Technologies
Omni Blast 100

APPENDIX E

NICO Pyrotechnik
Sound & Flash 1-Bang

APPENDIX F

Precision Ordnance
DD400 Mag Load

APPENDIX G

Precision Ordnance
T429

APPENDIX H

Pyrotechnic Specialties, Inc.
MK141 Mod 0