inch (5 cm) thick block of medium density (2 pounds per cubic foot or 0.032g/cm^3) polyurethane upholstery foam to simulate grassy or other uneven surfaces.

AFSL then began work to revise its standard for these devices to incorporate such a dynamic stability test. AFSL issued an interim revised voluntary standard in January 1993 (which is the current version of the standard). The Commission also collected samples of large multiple tube devices and tested them for tipover using the industry's dynamic stability test.(1 and 14)

2. Dynamic Stability Testing

After issuing the ANPR, the Commission staff devised a plan to develop a dynamic stability test that could provide a reliable performance standard for multiple tube devices. The staff's objective was to develop a test that could reliably distinguish between large multiple tube devices that are dangerously unstable and those that do not present an unreasonable tipover risk. Like the industry, the staff attempted to identify a test surface that would simulate grass (the surface believed to be commonly used for fireworks displays), and that would produce consistent results in repeated tests.

In order to accomplish this goal, the staff had to identify a surface on which the devices would consistently tipover or remain upright at the same rate as on grass. If the tipover rate was significantly greater on the test surface than on grass, the standard might be too stringent. If the tipover rate was significantly lower on the test surface than on grass, the standard might not adequately protect consumers. The staff's testing focused principally on large devices since these present the most serious hazard.

The staff tested large multiple tube devices in two phases. In phase I, three devices were tested on grass and on three types of foam. The type of foam that yielded tipover results closest to those on grass was to be used in phase II, where six additional devices were tested with grass and one type of foam.[2] All nine large multiple tube devices had inner tube diameters of at least 1.5 inches. Three devices (numbers 2, 3, and 4) were modified by trimming their bases, thereby increasing their tip-over rates. This was done to help assess the relationship between grass and foam by having a broad range of tipover rates among the devices.(6 and 8)

The staff took measurements of conditions during testing, such as wind-speed and temperature, and determined that these factors had little effect on the testing results. The staff also measured the level and topography of the ground used for testing on grass. This testing was conducted on typical field grass in the Leesburg, Virginia area. The grass area varied from mostly grass to a mixture of grass and weeds. Steps were taken to assure that the locations for tests on the field were randomly selected and were relatively level.(6, 7 and 8)

The staff began testing in phase I with 2-inch thick foams of three different densities. This thickness was chosen, in part, because the AFSL standard specifies 2-inch thick medium density foam. However, in the initial tests, the tipover rates with all three densities of two-inch thick foam were significantly greater than with grass (39–50 tipovers out of 50 on foam compared with 4 out of 50 on grass). Therefore, the experimental design was changed to include high density foam of three smaller thicknesses (0.75, 1.0, and 1.5 inches) in the hope of achieving better agreement in the tipover rates.(6 and 8)

The results of phase I are summarized in Table 1. None of the three foams agreed consistently with grass for all three devices. With device 1, only 0.75 inch foam agreed adequately with grass. With device 2 (unmodified), only 1.0-inch foam agreed. With device 3, none of the foams agreed with grass, although 1.5-inch foam came the closest. (Specifically, the tipover rates with all three foams were significantly lower than the rate with grass.) One-inch foam was chosen for phase II testing because it appeared to be the best overall choice among the three foams, i.e., it did not consistently underestimate or overestimate the tipover rates on grass.(6 and 8)

TABLE 1.—PHASE I—INCIDENCE AND PERCENTAGE OF TIPOVER WITH LARGE MULTIPLE TUBE DEVICES ON GRASS OR HIGH DENSITY POLYURETHANE UPHOLSTERY FOAM

Device	Grass	Polyurethane foam		
		0.75 inch	1.0 inch	1.5 inch
1	4/50 8%	4/50 8%	14/50* 28%	40/50* 80%
2[a]	32/50 64%	9/50* 18%	25/50 50%	43/50* 86%
3[a]	27/50 54%	2/50* 4%	3/50* 6%	7/50* 14%

* Significantly different from grass, P<0.05.
[a] Device modified to increase tipover rate.

In phase II, six additional devices were tested on grass and 1.0-inch thick high density foam. The results were then combined with the results from phase I (Table 2). Once again, there was not consistent agreement between the tipover rates on foam and on grass. Four devices (numbers 5, 7, 8, and 9) did not tip over in 50 tests each with grass and 1.0-inch thick foam. With device 2, the tipover rate with foam (25/50) did not differ significantly from that with grass (32/50). However, with device 3, the tipover rate with foam (3/50) was significantly *less* than that with grass (27/50). With devices 1 and 6, the tipover rate with foam was significantly *greater* than that with grass.(6 and 8)

TABLE 2.—PHASE II—INCIDENCE AND PERCENTAGE OF TIPOVER WITH LARGE MULTIPLE TUBE DEVICES ON GRASS OR 1.0-INCH HIGH DENSITY POLYURETHANE UPHOLSTERY FOAM

Device	Grass	Foam
1[a]	4/50 8%	14/50* 28%
2[b]	32/50	25/50

[2] Testing of a seventh device originally included in phase II was discontinued because burning material from the device started fires in the testing field.