

Working Paper

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Unannounced U.S.
Nuclear Weapons Tests, 1980-1984

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I. Introduction

On 29 January 1984 the New York Times reported that the Reagan Administration was not announcing all U.S. nuclear tests.¹ All U.S. nuclear tests conducted prior to the signing of the Limited Test Ban Treaty on August 5, 1963 (banning the testing of nuclear weapons in the atmosphere, in outer space, and in the water) were publicly announced by the U.S. government. From 1965 through 1979 thirty five tests, unannounced by the Department of Energy (DOE), were reported by other sources. An explicit policy to not announce all tests was adopted by the Reagan Administration in 1982.² Data are now available which permit one to estimate the number of U.S. tests that were unannounced by the U.S. government during the five year period 1980 through 1984.

II. Distribution of U.S. Nuclear Weapon Test Yields

The distribution of U.S. nuclear weapons tests as a function of yield for the five year period 1980 through 1984 has been published by Ray E. Kidder of the Lawrence Livermore

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- 1 William J. Broad, "Some Atomic Tests Being Kept Secret by Administration," New York Times, January 29, 1984, p. 1.
 - 2 Excerpt from memorandum dated April 2, 1982, from W.W. Hoover to M.E. Gates; subject: "Planning Directive for Underground Nuclear Tests at the Nevada Test Site". Enclosure to letter from John E. Rudolph, DOE, to Robert S. Norris, December 23, 1985.

National Laboratory.³ The distribution, which includes both announced and unannounced tests, is reproduced in Figure 1. All of the tests were conducted underground for military purposes at the Nevada Test Site (NTS). The distribution in Figure 1 was generated from the discrete yield data by applying a smoothing function. Kidder has also provided several values of the cumulative distribution function P, the percentage of tests conducted with yield less than Y, versus Y (reproduced in Table 1).

III. Analysis

The U.S. Department of Energy has announced 82 nuclear weapons tests conducted during the 1980 through 1984 period with the following distribution in yields⁴:

<u>No. of Tests</u>	<u>Yield</u>
44	less than 20 kt
35	20-150 kt
<u>3</u>	less than 150 kt ⁵
82	total (all less than 150 kt)

³ Ray E. Kidder, "Militarily Significant Nuclear Explosive Yields", F.A.S. Public Interest Report, 38, September 1985, pp. 1-3; this paper was first presented at the DOE sponsored Cavity Decoupling Workshop, Pajaro Dunes, California, July 29-31, 1985 (the workshop paper was dated June 25, 1985).

⁴ DOE, "Announced United States Nuclear Tests, July 1945 through December 1984, NVO-209 (Rev. 5), Nevada Operations Office, January 1985; includes eight joint US-UK tests.

⁵ These three events are Shot Borrego (September 29, 1982 Greenwich Civil Time), Shot Turquoise (April 14, 1983 GCT) and Shot Techado (September 22, 1983 GCT).

According to Kidder, 38 percent of all tests were 20 kt or greater (see Table 1). Consequently the total number of tests in the 5-year period was at least $92+1$, since 35 tests or more had yields 20 kt or greater, and the number of unannounced tests was at least 9 ($10+1$).

It is reasonable to assume that all unannounced tests were less than 20 kt, since higher yield tests would be readily detected by seismic stations abroad. Since there were 35 to 38 announced tests with yields 20 kt or over, the total number of tests, announced and unannounced, conducted at NTS from 1980 through 1984 may be as large as 101:

<u>If Announced</u> <u>Tests \geq 20kt</u>	<u>Total</u> <u>Tests</u>
35	92 + 1
36	95 + 1
37	97 + 1
38	100 + 1

Therefore, the number of tests unannounced by DOE during the 5 year period was 9 to 19, inclusively.

This range can be narrowed somewhat by comparing measured values of m_b , the body wave magnitude, of the three ambiguous events listed as "less than 150 kt", with m_b values of announced tests in the two yield ranges 0-20 kt and 20 to 150 kt. The m_b value for one of the three ambiguous tests, Shot Turquoise (on April 14, 1983 Greenwich Civil Time), was 5.7 as reported by the

U.S. Geological Survey (USGS)⁶ and 6.1 as measured by the Hagfors Observatory of the Swedish National Defence Research Institute⁷. According to the U.S. Energy Research and Development Administration (now DOE), "In general, an event of 20-kiloton yield or less will produce a seismic signal of body wave magnitude (m_b) of 4.8 or less: an event within the range of 20 kilotons to 200 kilotons yield will produce a signal between 4.8 and 5.7 m_b ; and for an event between 200 kilotons and 1000 kilotons, the signal will be between 5.7 and 6.3 m_b ."⁸ Thus, the yield of Shot Turquoise is clearly above 20 kilotons and appears to be near the 150 kiloton limit of the Threshold Test Ban Treaty. Recategorizing the yield of shot Turquoise as 20-150 kt increases the minimum number of unannounced tests from 9 to 12.

Values of m_b for the other two ambiguous shots (Borrego and Techado) have not been published by either the USGS, the Hagfors Observatory or the International Seismological Center. Based on the limited seismic information that is available, it is believed that if the tests were conducted in dry alluvium the yields would be in the vicinity of 20 kt; if conducted in hard rock they would

6 U.S. Department of Interior/Geological Survey, "Preliminary Determination of Epicenters", April 1983, p. 7.

7 Stockholm International Peace Research Institute, "SIPRI Yearbook 1985", p. 80.

8 U.S. Energy Research and Development Administration, "Final Environmental Impact Statement, Nevada Test Site", September 1977, p. 2-75.

be below 20 kt.⁹ Lacking conclusive information these two shots cannot be categorized at this time as above or below 20 kt.

Of the 12 to 19 unannounced tests from 1980 through 1984, eight are readily identified in the U.S. Geological Survey's "Preliminary Determination of Epicenters." These are reproduced in Table 2. Five of the eight were also reported as weapons tests by the Hagfors Observatory.¹⁰ A ninth event at Yucca Flats on the Nevada Test Site also may be a weapons test, however, its time of occurrence during the night suggests it is more likely an earthquake.¹¹

From January 1935 to September 1961 "there were 23 seismic events located on NTS (less than one event per year), all with magnitude less than 4.5"¹²

Assuming a total of 95 tests (and data from Figure 1), the distribution of their explosive yields are presented in Table 3, Column 2. We have also tabulated the yield frequency assuming totals of 97 and 100 tests (Columns 3 and 4).

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- 9 Dr. Lynn Sykes, Higgins Professor of Geological Sciences, Lamont-Doherty Geological Observatory of Columbia University, private communication, December 1985.
- 10 SIPRI Yearbook, p. 80. The five events are identified by a (*) in Table 2.
- 11 This event is reported by the USGS to have occurred on December 19, 1982 at 04 hr 31 min 15.3 sec GCT at 37.113 N and 116.000 W. In contrast, all unannounced tests listed in Table 2 are reported to have occurred between 1400 and 1814 GCT and within 0.8 seconds of the minute.
- 12 U.S. ERDA, FEIS, Nevada Test Site, p. 2-72.

IV. Conclusion

During the period of interest, 1980 through 1984, the Hagfors Observatory operated by the National Defense Research Institute of Sweden detected five underground nuclear tests at NTS which were unannounced by DOE (on August 27, 1983, December 9, 1983, May 2, 1984, May 16, 1984 and July 12, 1984 GCT). Thus the Hagfors Observatory was unable to detect 8 ± 1 unannounced tests; and 10 ± 1 or 13 ± 1 if two or all of the three tests listed by DOE as "less than 150 kt" were actually less than 20 kt. It is reasonable to assume that the Hagfors Observatory seismic array failed to detect the lowest yield tests. This implies that they cannot reliably detect underground tests at NTS below about 2-3 kt (see Table 3).

The seismic stations utilized in the USGS reports detected at least eight of the 12 to 19 unannounced tests. The sensitivity of the seismic stations utilized by the USGS (at least to the extent that the results are reported) is in the 1-2 kt range.

With regard to verifying a comprehensive test ban, if seismic stations were established specifically to detect weapons tests, the threshold would be even lower. It has been reported that the Norwegian Regional Seismic Array of 26 seismometers,

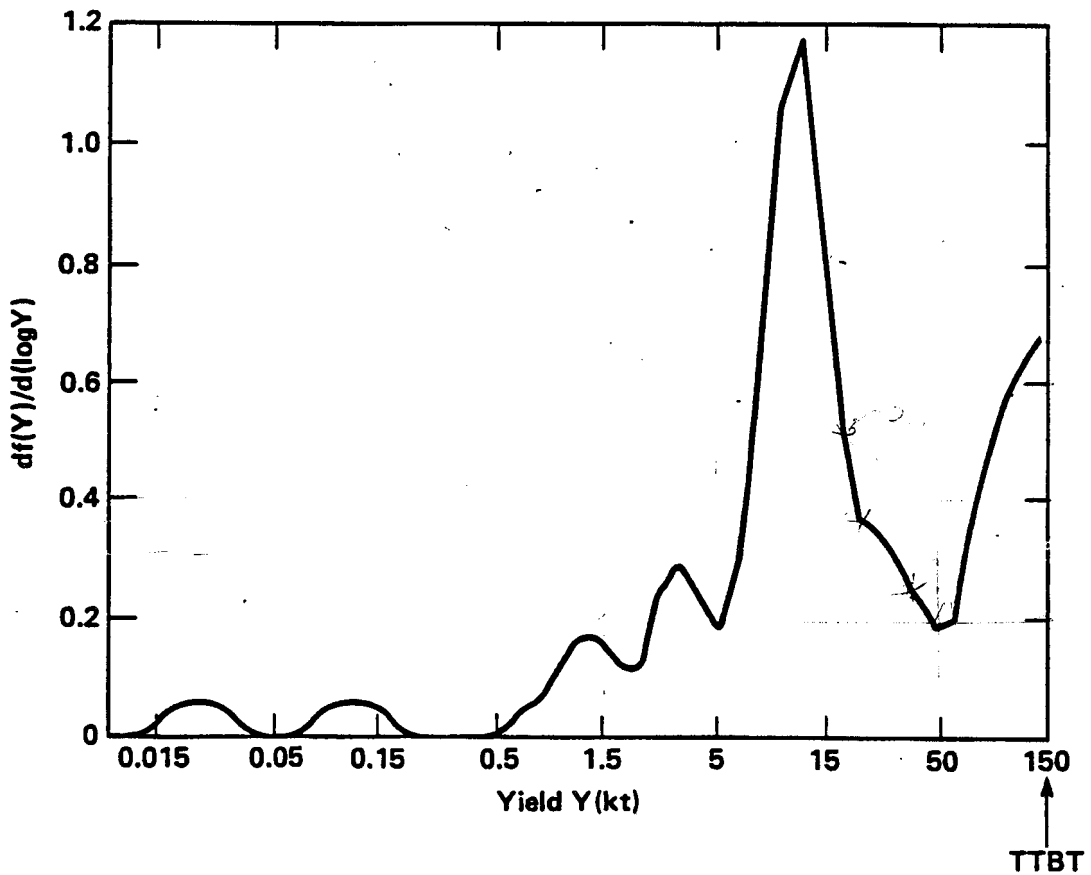
designed by Lawrence Livermore and Sandia National Laboratories can detect an explosion "of about one-half kiloton" at the Soviets central test site 2600 miles away.¹³

13 Walter Pincus, "U.S. Bars Nuclear Test-Ban Talks Until Stockpiles Are Reduced," Washington Post, 21 November 1985, p. A30. See also, Walter Pincus, "U.S. Detects Soviets' Smallest Nuclear Tests," Washington Post, 10 August 1985, p. A15.

Figure 1

Distribution of Explosive Yields
at NTS: 1980 through 1984

The curve plotted shows the relative frequency with yield Y versus that yield for all tests at the Nevada Test Site (NTS) from 1980 through 1984. The vertical scale is designed to produce an area under the curve of one so that the relative probability of a test being given yield Y can be seen immediately.



$f(Y)$: Fraction of Tests with Yield Less Than Y
(No Yields Above 150kt)

Table 1

Percentage P of tests conducted
with yield less than Y.

Y (kt)	1	5	20	50	150
P (%)	5	18	62	74	100
	5	17	50	70	
	5.2	17.2	50.2	70.2	

Table 2

<u>Date</u>	<u>Time</u>	<u>(UTC)</u>	<u>Lat</u>	<u>Long</u>	<u>Depth</u>	<u>m_b</u>	<u>No. of Sta.</u>	<u>ML</u>
Aug 27, 1983*	13.59	59.9	37.192N	115.992W	5	4.1	20	4.2 (Berkeley)
Sep 21, 1983	16.24	59.7	37.113N	116.043W	3	?	20	4.2 (Berkeley)
Dec 9, 1983*	15.59	59.2	37.021N	115.975W	2	?	22	4.0 (Berkeley)
May 2, 1984*	13.49	59.6	37.189N	116.016W	5	?	17	3.3 (Berkeley)
May 16, 1984*	15.59	59.3	37.091N	115.994W	5	?	10	3.5 (Berkeley)
Jul 12, 1984*	13.59	59.9	37.186N	116.012W	5	3.6	19	3.8 (Berkeley)
Oct 2, 1984	18.13	59.3	37.076N	115.989W	2	4.2	34	4.3 (Berkeley)
Dec 20, 1984	16.19	59.7	36.979N	116.006W	2	4.2	22	4.2 (Berkeley)

Source: U.S. Geological Survey, "Preliminary Determination of Epicenters", issued monthly.

* Also reported by Hagfors Observatory of the Swedish National Defence Research Institute. See SIPRI Yearbook 1985, pp. 80-81.

Table 3

Cumulative Distribution of U.S. Nuclear Weapon Test Yields
(1980-1984)

Yield (kt)	Total =	95	97	100
0.015		.45	.46	.48
0.02		.78	.80	.83
0.03		1.24	1.26	1.30
0.04		2.55	2.61	2.69
0.05		2.55	2.61	2.69
0.07		2.58	2.63	2.71
0.09		2.84	2.90	2.99
0.1		2.97	3.03	3.12
0.12		3.19	3.26	3.36
0.14		3.39	3.46	3.56
0.16		3.52	3.60	3.71
0.2		3.52	3.60	3.71
0.5		3.52	3.60	3.71
0.8		4.15	4.24	4.37
1		4.75	4.85	5.00
1.2		6.04	6.16	6.35
1.4		7.12	7.27	7.50
1.5		7.61	7.77	8.01
1.85		8.62	8.80	9.07
2.24		9.60	9.80	10.10
2.7		11.66	11.90	12.27
3.35		14.06	14.35	14.80
5		17.10	17.46	18.00
6.2		19.57	19.99	20.60
9		34.21	34.93	36.01
10		38.63	39.44	40.66
12		46.50	47.48	48.95
15		54.11	55.25	56.96
17.5		57.11	58.31	60.12
20		58.90	60.14	62.00
27.5		64.37	65.72	67.75
30		65.71	67.09	69.17
50		70.30	71.78	74.00
65		74.09	75.65	77.99
75		76.96	78.58	81.01
85		80.09	81.78	84.31
90		81.57	83.29	85.86
100		84.58	86.36	89.03
110		87.42	89.26	92.02
120		90.08	91.98	94.82
130		92.59	94.54	97.46
140		95.00	97.00	100.00
150		95.00	97.00	100.00

Nuclear Weapons Databook Publications

"The U.S. Nuclear Stockpile: Materials Production and New Weapons Requirements." William M. Arkin, Thomas B. Cochran and Milton M. Hoenig. Arms Control Today, April 1982.

Nuclear Weapons Databook, Volume I U.S. Nuclear Forces and Capabilities. Thomas B. Cochran, William M. Arkin, Milton M. Hoenig. Cambridge, Massachusetts: Ballinger Publishing Company, 1984. \$19.95 pb.

"The Soviet Nuclear Stockpile." William M. Arkin and Jeffrey I. Sands. Arms Control Today, June 1984.

"Resource Paper on the U.S. Nuclear Arsenal." William M. Arkin, Thomas B. Cochran and Milton M. Hoenig. Bulletin of the Atomic Scientists, August/September 1984.

"Nuclear Weapons." William M. Arkin, Andrew S. Burrows, Richard W. Fieldhouse, Thomas B. Cochran, Robert S. Norris, Jeffrey I. Sands. World Armaments and Disarmament: SIPRI Yearbook 1985.

"A Review of Soviet Military Power 1985." Jeffrey I. Sands. June 1985. Nuclear Weapons Databook Working Paper 85-2. \$5.00.

"History of the Nuclear Stockpile." Robert S. Norris, Thomas B. Cochran, William M. Arkin. Bulletin of Atomic Scientists, August 1985.

"Counterforce at Sea: The Trident II Missile." Robert S. Norris. Arms Control Today, September 1985.

"Unannounced U.S. Nuclear Weapons Tests, 1980-84." Thomas B. Cochran, Robert S. Norris, William M. Arkin, Milton M. Hoenig. January 1986. Nuclear Weapons Databook Working Paper 86-1. \$2.00.

"Known U.S. Nuclear Tests, July 1945 to 31 December 1985." Robert S. Norris, Thomas B. Cochran, and William M. Arkin. February 1986. Nuclear Weapons Databook Working Paper 86-2. \$5.00

"Known Soviet Nuclear Explosions, 1949-1985, Preliminary List." Jeffrey I. Sands, Robert S. Norris and Thomas B. Cochran. February 1986. Nuclear Weapons Databook Working Paper 86-3. \$5.00

"Nuclear Weapons." William M. Arkin, Andrew S. Burrows, Thomas B. Cochran, Richard W. Fieldhouse, Robert S. Norris, Jeffrey I. Sands. World Armaments and Disarmament: SIPRI Yearbook 1986.