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Nuclear Explosions 1945 - 1998

Nils-Olov Bergkvist
Ragnild Ferm



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The picture on the front cover shows numerous cables laid out at an underground nuclear test location at Yucca Flat, Nevada. Yucca Flat was the principle underground nuclear weapons testing area at the Nevada Test Site, United States. The cranes in the picture were used to lower the cable "down-hole" with the nuclear weapon canister. Scientific data was communicated through the cables to recording trailers on the surface. The tower was used to hold the instrumentation canister; the tower was removed before the nuclear device was detonated. The drill emplacement hole is beneath the tower. The picture has been down-loaded (by permission) from the web-site of **Nevada Division of Environmental Protection Bureau of Federal Facilities**.

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Nuclear Explosions 1945 - 1998

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Abstract <p>The main part of this report is a list of nuclear explosions conducted by the United States, the Soviet Union, the United Kingdom, France, China, India and Pakistan in 1945–98. The list includes all known nuclear test explosions and is compiled from a variety of sources including officially published information from the USA, Russia and France. The details given for each explosion (date, origin time, location, yield, type, etc.) are often compiled from more than one source because the individual sources do not give complete information. The report includes a short background to nuclear testing and provides brief information on the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and the verification regime now being established to verify compliance with the treaty. It also summarizes nuclear testing country by country. The list should be used with some caution because its compilation from a variety of sources means that some of the data could be incorrect. This report is the result of cooperation between the Defence Research Establishment (FOA) and the Stockholm International Peace Research Institute (SIPRI).</p> <p>An electronic version of the list may be obtained from FOA on request.</p>		
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Sammanfattning Huvudsyftet med denna rapport är att i komprimerad form redovisa en fullständig lista över kärnladdnings- explosioner som genomförts av USA, Sovjetunionen, Storbritannien, Frankrike, Kina, Indien och Pakistan under tiden 1945–98. Listan baseras på ett flertal källor, inklusive officiell information från USA, Ryssland och Frankrike. Eftersom källorna var för sig inte ger en komplett bild, är den information som redovisas för varje explosion (datum, källtid, lokalisering, laddningsstyrka, typ etc.) ofta hämtad från flera källor. Rapporten innehåller också en kortfattad historik över ländernas provverksamhet och en summering av provstoppsavtalet samt en sammanställning av antalet kärnexplosioner utförda av de sju staterna. Informationen i listan bör användas med viss försiktighet, eftersom uppgifterna har hämtats in från många olika källor och viss informa- tion kan vara felaktig. Vissa korrekturfel i listan är oundvikliga. Rapporten är resultatet av ett samarbete mellan Försvarets forskningsanstalt (FOA) och Stockholms internationella fredsforskningsinstitut (SIPRI). Listan finns tillgänglig i elektronisk form på FOA.		
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PREFACE

Discussions between the authors of this report about the annual numbers of nuclear tests conducted since 1945 finally led to a joint undertaking to compile a list of nuclear explosions that would satisfy us both. Our aim was also to present as much information as possible concerning the tests. While the list presented here draws on a wide range of sources, the core data are those compiled by FOA, which were first computerized in the early 1980s (when Tom Francke compiled an ASCII file based on various paper sources). During the past few years more and more information on tests has become available as various authoritative sources have published data based on declassified documents and information on nuclear powers' testing programmes. This has enabled us to make our list more accurate.

Brief background information on nuclear explosions and a country-by-country summary of testing activity is also included. The report is intended for a broad audience, and it is hoped that it will stimulate further research and debate on nuclear testing and test ban issues.

The authors would like to thank Eva Norrbrand for managing the production of the report and Billie Bielckus for editorial assistance.

1. BACKGROUND INFORMATION ON NUCLEAR EXPLOSIONS

1.1. INTRODUCTION

More than 2000 nuclear explosions have been conducted since 1945. Nuclear weapons have been used twice in war: by the USA in August 1945, at the end of World War II, on the Japanese cities of Hiroshima and Nagasaki.

Most of the other nuclear explosions have been detonations intended to test the construction of the devices (weapon tests) or their effect.

No atmospheric tests have been conducted by the USA, the Soviet Union/Russia or the UK since 1963, when the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (the Partial Test Ban Treaty, PTBT) was signed. France confined its activities to underground testing from 1974, and China from 1980. Before 1963 a few tests were also conducted under water.

The Comprehensive Nuclear-Test-Ban Treaty (CTBT), signed in 1996, has not yet entered into force.

1.2. TYPES OF NUCLEAR EXPLOSION

Nuclear explosions can be divided into two main categories: atmospheric and underground. In the atmospheric tests the device was placed in a tower or on a boat, dropped from an aeroplane or a balloon, fired by a missile or detonated on the ground. All these tests led to the spread of radioactive debris in the upper layers of the atmosphere, which then fell to the ground, often over very wide areas.

Underground tests have been conducted in tunnels or deep shafts. A hole (up to *c.* 1 km deep for larger devices, a few hundred metres for smaller ones) was drilled into the bedrock, and the nuclear devices and measuring instruments were placed in the bottom. The entire borehole was refilled to prevent radioactive material from leaking out. The explosion was registered by the monitoring instruments on the container microseconds before they were destroyed. The heat of the explosion melted and vaporized the bedrock, and the pressure created a cavity and caused vibrations in the ground. A crater was usually formed, its size depending on the kind of rock and the yield of the explosion.

Sometimes underground tests also led to the discharge of radioactivity. In Sweden during the period 1966–90 the Defence Research Establishment (FOA), which has monitored airborne radioactivity from nuclear detonations since the 1950s, registered the leakage of radiation from six Soviet and two US underground nuclear tests (in violation of the PTBT). The nuclear weapon states presumably have information on more discharges of radioactivity in their registers. The French test site in Polynesia lies too far away to be monitored from Sweden, but radioactive materials from the southern Pacific Ocean have been collected and examined in Sweden.

NUCLEAR DEVICES

There are two main kinds of nuclear device: those based entirely on fission, or the splitting of heavy atomic nuclei (previously known as *atomic devices*) and those in which the main energy is obtained by means of fusion, or of light atomic nuclei (*hydrogen* or *thermonuclear devices*). A fusion explosion must however be initiated with the help of a fission device. The strength of a fusion explosion can be practically unlimited. The explosive power of a nuclear explosion is expressed in kilotons (kt) or megatons (Mt), which correspond to 1000 and 1 million tonnes of conventional explosive (TNT), respectively.

So-called peaceful nuclear explosions (PNEs) have also been carried out. They were often conducted outside the usual test sites and it was claimed that they were for civil purposes. There is no major distinction between nuclear devices detonated for civil or for military purposes, and it should be pointed out that even so-called peaceful nuclear explosions could provide valuable experience for weapon development.

1.3. US NUCLEAR EXPLOSIONS

The first nuclear weapon test was conducted in the USA—at Alamogordo, New Mexico, on 16 July 1945—and was a result of the so-called Manhattan Project, which had been underway since 1942. It was a plutonium device that was tested, and the same construction was to be used some weeks later in the bombing of Nagasaki, a port in south-west Japan. Three days earlier, on 6 August, the USA had

dropped the first atomic bomb, a uranium bomb, on Hiroshima, another port in south-west Japan. The Hiroshima bomb had not been tested before it was used in war.

Nuclear weapon development continued in the USA and tests were conducted in 1946–62 at various atolls and islands in the Pacific Ocean. The first hydrogen bomb was tested in 1951, at Enewetak Atoll, then part of a UN Trust territory administered by the USA, now part of the Marshall Islands. Only small groups among those working on the tests knew how harmful the fall-out from the explosions was for people and the environment. Certain atolls used for the US tests in the 1950s are still uninhabitable today because of the radioactivity.

The need for a closer testing ground grew as the US nuclear weapon programme expanded. There was also a desire to reduce the cost of the testing activity. The Nevada test site was first used in 1951, but the tests in the Pacific Ocean continued up to November 1962. At first atmospheric tests were also held in Nevada (with consequences for people and the environment there too), but there was a gradual transition to solely underground testing.

A programme for civil nuclear explosions, the *Plowshare* project, was started in 1957. The first explosion was conducted in 1961, the last in 1973. The idea was to investigate whether the military capacity could be converted to civil purposes ('swords to ploughshares'). For example there were plans to blast a new Panama Canal, with no locks. The *Plowshare* project was abandoned in the mid-1970s. It became apparent that it was impossible to benefit from the peaceful nuclear explosions for a reasonable cost without destroying the environment. The USA also conducted seven so-called *Vela Uniform* tests, designed to detect, identify and locate nuclear explosions.

The USA last tested a nuclear device in September 1992. To maintain the skills of those working at the test site and to control the reliability of its existing nuclear weapons the USA is carrying out so-called subcritical tests at the Nevada Test Site.¹

¹ Subcritical tests use conventional high explosives to create high pressures on nuclear weapon material without allowing it to become critical (i.e., a self-sustaining nuclear fission chain reaction). Protests have been raised by those who claim that although subcritical tests are not forbidden by the 1996 Comprehensive Nuclear Test-Ban Treaty (CTBT), they violate the spirit and aims of the treaty because they may contribute to the improvement of weapon designs.

NUCLEAR WEAPON STATES

In the Non-Proliferation Treaty a nuclear weapon state is defined as 'a state which has manufactured and exploded a nuclear weapon or other nuclear explosive device prior to 1 January, 1967'. The USA, the Soviet Union/Russia, the UK, France and China meet this criterion. They are often called the 'established' or 'NPT-defined' nuclear weapon states. With their nuclear explosions in May 1998 India and Pakistan demonstrated their ability to develop nuclear weapons and declared themselves nuclear weapon states. This claim has been rejected, however, by the international community.

1968 NON-PROLIFERATION TREATY

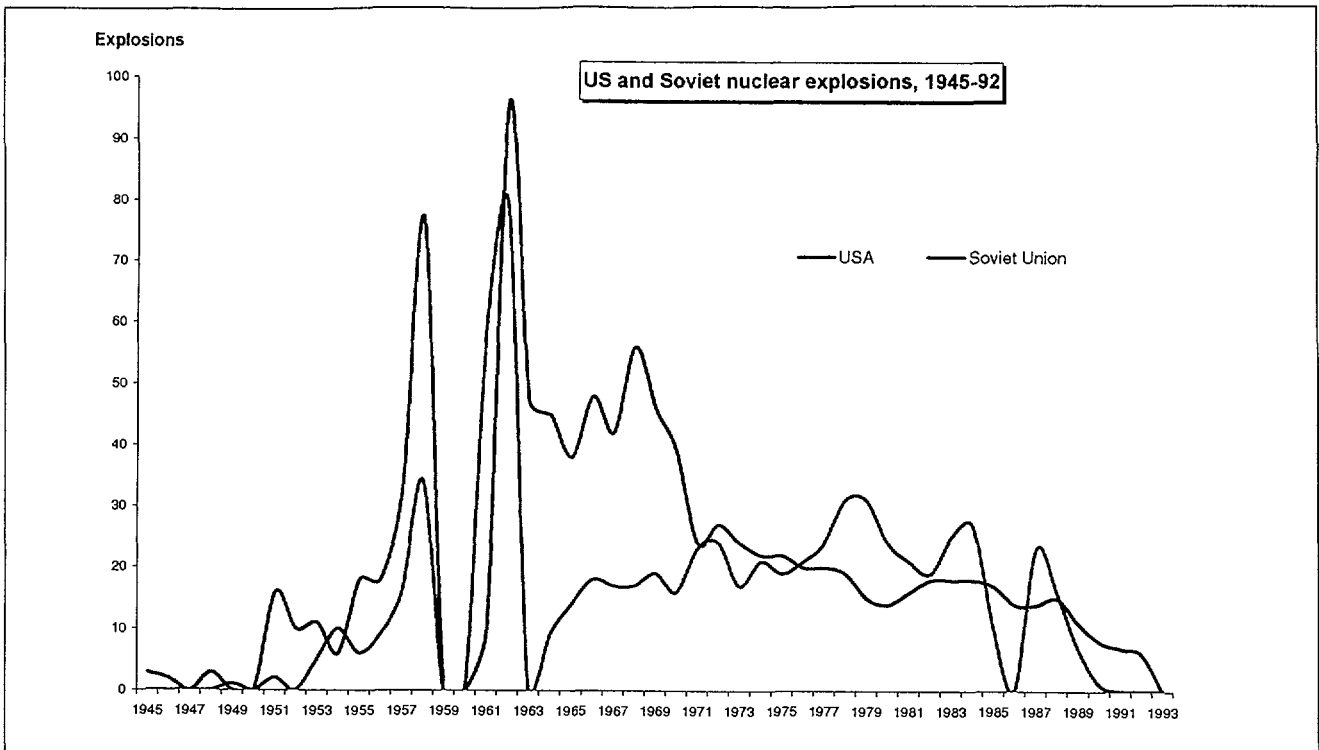
Under the Treaty on the Non-Proliferation of Nuclear Weapons (the Non-Proliferation Treaty, NPT), the nuclear weapon states undertake not to transfer nuclear weapons or other nuclear explosive devices or control over them to any recipient whatsoever, and not to assist, encourage or induce any non-nuclear weapon state to manufacture or otherwise acquire nuclear weapons. The parties also pledge to work towards nuclear disarmament.

Non-nuclear weapon states undertake not to accept nuclear weapons or other nuclear devices and not to manufacture or otherwise acquire nuclear weapons and not to seek or receive any assistance for their manufacture.

A non-nuclear weapon state party to the treaty shall enter an agreement with the International Atomic Energy Agency (IAEA) on opening up its nuclear energy sector to control. The IAEA shall monitor that no significant amount of fissionable material goes astray. Non-nuclear weapon states parties to the treaty are guaranteed the right to develop research, production and use of nuclear energy for peaceful purposes.

The USA has conducted 1032 nuclear explosions:

- 2 atomic bombs dropped on Hiroshima and Nagasaki
- 106 tests in the Pacific Ocean (101 atmospheric, 5 underwater)
- 3 tests in the southern Atlantic (in the atmosphere)
- 904 tests at the Nevada Test Site (100 in the atmosphere, 804 underground)
- 17 underground explosions at other locations in the USA
- (The USA also cooperated in the 24 tests conducted by the UK at the Nevada Test Site)



1.4. SOVIET NUCLEAR EXPLOSIONS

The Soviet Union carried out its first nuclear explosion on 29 August 1949, and thus the nuclear arms race was initiated. In August 1953 the first Soviet hydrogen bomb test was conducted. The USSR conducted a number of very high yield explosions in the atmosphere in 1961–62. No official details on the size of the tests were published by the Soviet side then, but it was known for example that the test conducted on 30 October 1961, over the Novaya Zemlya archipelago in the Barents Sea, had a yield of about 50 megatons. (The Hiroshima bomb was calculated to have had a yield of 12–15 kilotons.) Most of the Soviet explosions were carried out at the Semipalatinsk test site in eastern Kazakhstan. It has been reported that radioactive materials leaked out from many of the underground explosions there, in c. 40 cases in large amounts. When Kazakhstan became an independent state the test site was closed (1991). In 1993, 1994 and 1998 the International Atomic Energy Agency (IAEA), at the request of Kazakhstan, made investigations at the former test site. Elevated residual radioactivity levels were found in areas where surface tests had been conducted and where underground tests had leaked to the atmosphere. The other Soviet test site, on Novaya Zemlya, is located on Russian territory and

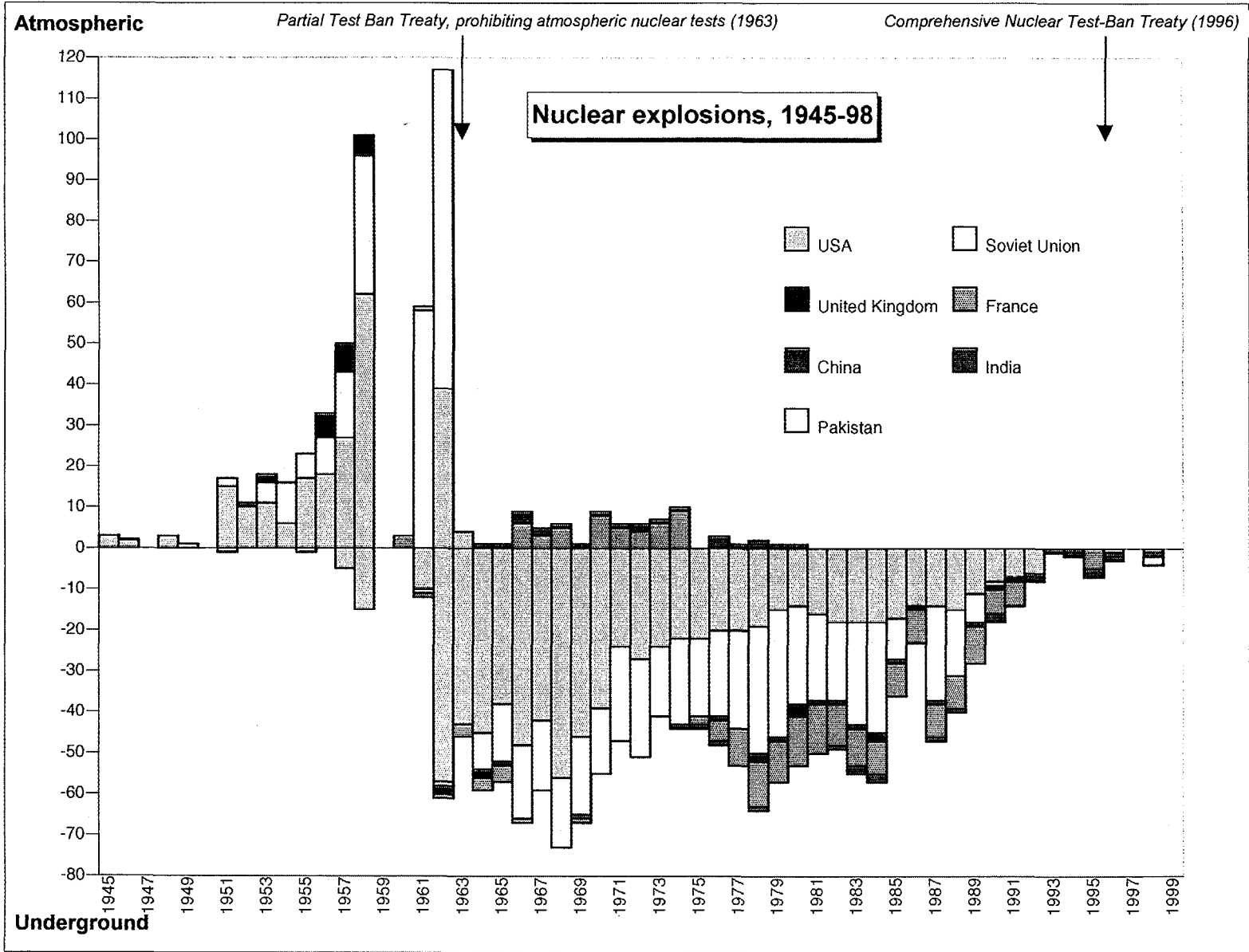
still exists, but since Russia ceased nuclear testing (1990) it has only been used for subcritical tests.

The Soviet Union conducted more than 120 peaceful nuclear explosions (PNEs), the last in September 1988. The explosions were carried out, for example, to obtain seismological information on mineral resources, to create underground rock cavities for gas reservoirs or to excavate channels to combine rivers (this was unsuccessful). The PNEs were very damaging to the environment and human beings because radioactive particles eventually made their way to the surface.

The Soviet Union was dissolved in 1991, and Russia took over the Soviet nuclear weapon programme. Russia has conducted neither nuclear weapon tests nor any peaceful nuclear explosions. Subcritical tests have been carried out since 1995.

The Soviet Union conducted 715 nuclear explosions:

- 456 at the Semipalatinsk test site (116 in the atmosphere and 340 underground)
- 130 on Novaya Zemlya (88 in the atmosphere, 3 underwater and 39 underground)
- 129 at various other places in the USSR—in Russia (e.g., in the Arkhangelsk, Astrakhan, Krasnoyarsk and Murmansk regions), Kazakhstan, Turkmenistan, Ukraine and Uzbekistan—most of them for civil purposes.



1.5. BRITISH NUCLEAR EXPLOSIONS

British scientists took part in the US Manhattan Project, which created the first nuclear explosive devices. Their cooperation with the USA was broken off at the end of World War II, and the UK's nuclear weapon development continued as a British project. Australia was chosen as the location for tests, and the first British nuclear weapon test was carried out in October 1952, at the Monte Bello Islands off the north-west coast of Australia. Further tests were held there, and also on the Australian mainland. It was later evident that people—mainly aborigines—and the environment suffered considerable damage as a result of the fall-out from the tests in Australia. An Australian Commission was established in 1984 to investigate the circumstances surrounding the tests. Testing activities also took place on the British possessions Malden Island and Christmas Island (now Kiribati) in the Pacific Ocean. Several hydrogen bomb tests were conducted there in 1957–58.

Since March 1962 the UK used the US test site in the Nevada Desert for nuclear weapon tests in cooperation with the USA. The UK only conducted underground tests there; the last one was in November 1991. The testing programme was discontinued after 1992 because of the US moratorium.

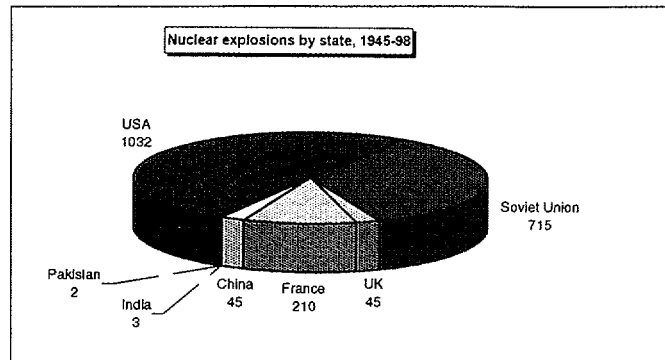
The UK has conducted 45 nuclear explosions:

- 12 atmospheric tests in Australia
- 9 atmospheric tests in the Pacific Ocean (Malden Island and Christmas Island)
- 24 underground tests (in cooperation with the USA) in Nevada

1.6. FRENCH NUCLEAR EXPLOSIONS

In 1958 President de Gaulle decided that France would develop its own nuclear weapons, and nuclear cooperation with other Western powers was cancelled. Algeria, then a French possession, was chosen as the location for the tests, and the first explosion took place there in February 1960. In total France conducted 17 tests in Algeria, the first four in the atmosphere, at Reganne in the Sahara Desert. These tests were conducted during a period when the

other nuclear weapon powers were observing a moratorium, and France was therefore criticized internationally. This was probably one reason why the next 13 tests in Algeria (1961–66) were conducted underground, at In Ecker, some 500 km south-east of Reganne.



Algeria became independent in 1962 and France was forced to end its testing activity there. A new test site was created at the Mururoa Atoll in French Polynesia, and atmospheric explosions were resumed there in 1966. The Fangataufa Atoll, *circa* 40 km south-west of Mururoa, was also used. The first French hydrogen bomb was tested there in August 1968. After 1974 France conducted underground nuclear explosions instead, a concession to international criticism.

In the beginning the underground tests on Mururoa and Fangataufa were conducted in boreholes in the ground, but as the holes became more numerous and it was feared that this would damage the atoll, holes were bored beneath the lagoon of the atoll instead. The bedrock in an atoll is composed of basalt, a more brittle rock than granite, which is the bedrock in the areas where the Soviet Union conducted its underground tests, for example. Over the years France was criticized throughout the world for locating its testing activity in an area far from the mainland, where it was the local population that suffered from the damage to the environment and human life. The possible damages to the marine environment have been discussed, and France commissioned the IAEA to investigate the Mururoa and Fangataufa atolls. The study concluded that the sediments in the lagoons contained several kilograms of residual plutonium, and that elevated levels of caesium-137 remained in small areas of the atolls. However, it was stated that the residual radioactive material was not expected to have any measurable health effects on individuals or groups.

After its last test, in January 1996, France wound down its facility in French Polynesia. The test site was officially closed in 1999. Thus France is the first nuclear weapon state to really shut down its test sites.

France has conducted 210 nuclear explosions:

- 17 in Algeria (4 atmospheric tests at Reganne, and 13 underground tests at In Ecker)
- 193 in French Polynesia (42 atmospheric tests and 138 underground tests at Mururoa and 4 atmospheric and 9 underground tests at Fangataufa)

1.7. CHINESE NUCLEAR EXPLOSIONS

China conducted its first nuclear weapon test in October 1964. The country had then had a nuclear weapon programme for nearly 10 years, initially with Soviet support. When the relationship between the two powers deteriorated at the end of the 1950s China had to rely wholly on its own resources. The development of a nuclear weapon capability was given highest priority, and despite the country's great poverty and lack of scientific expertise the programme was carried through.

All China's nuclear explosions have been carried out in the Lop Nor area, a desert in the Sinkiang province of Western China. Its first hydrogen bomb test was conducted in 1966. China conducted all its tests in the atmosphere until 1980, when it changed to underground testing. That China accounts for some 2 per cent of the world's nuclear explosions has been emphasized by the Chinese Government on a number of occasions.

In July 1996, approximately two months before it signed the Comprehensive Nuclear-Test-Ban Treaty (CTBT), China announced that it would cease testing.

China has conducted 45 nuclear explosions,

- all at the Lop Nor test site:
- 23 atmospheric tests
- 22 underground tests

1.8. INDIAN AND PAKISTANI NUCLEAR EXPLOSIONS

India and Pakistan are not numbered among the five established nuclear weapon states. They have chosen to remain outside the NPT regime and, like Israel, have sites not controlled by the IAEA at which fissionable material for weapon production could be produced. All three have therefore been defined as threshold states. India exploded a nuclear device in 1974, at Pokhran in the Rajasthan desert in eastern India. It was claimed to have had a peaceful purpose.

On 11 and 13 May 1998 India conducted a series of nuclear weapon explosions at the Pokhran test site. At the end of the same month Pakistan responded with a further series of explosions. Pakistan's first test was conducted at the Ras Koh test site, in the Chagai Mountains in Baluchistan, near the Afghan border. The second test took place c. 100 km south-west of Ras Koh, in the Kharan desert. The tests were greeted by international criticism because it was felt that they counteracted the efforts to extend the test ban treaty to all states. India later declared that it would observe a moratorium on testing. Pakistan has promised that it will also do so as long as India does not break its moratorium. Neither country has yet (1 July 2000) signed the CTBT.

1.9. SOUTH AFRICA

South Africa announced in 1993 that the country had had a nuclear weapon programme during the 1970s and 1980s, but that the six devices that had been produced had since been destroyed. In September 1979 a mysterious double flash was observed over the ocean south of South Africa at the same time as a US satellite registered signals that could indicate a nuclear explosion. There was speculation that South Africa and/or Israel could have been behind the possible explosion. No radioactive fall-out was noted. South Africa has stated that the country has never conducted a nuclear explosion. It is now a party to the NPT and has signed and ratified the CTBT.

1.10. MORATORIA

Over the years the individual nuclear weapon states have undertaken voluntary halts (moratoria) in their testing activity. The UK, the USA and the USSR observed such a moratorium from November 1958 to September 1961. President Gorbachev announced a moratorium in July 1985 but, as the USA never took part, both weapon tests and civil nuclear explosions were resumed in February 1987. A new Soviet moratorium began in October 1990. After the dissolution of the Soviet Union it was extended by the Russian Government, which declared that no further nuclear weapon tests would be conducted as long as the political situation did not deteriorate.

In 1992 President Bush declared a 9-month halt to US nuclear testing. President Clinton extended the moratorium to September 1994 or beyond, under the condition that no other state conducted a test explosion. Despite China resuming its test programme, and despite France conducting its series of tests in September 1995–January 1996, the USA chose not to resume testing.

The French moratorium (July 1991–September 1995) was followed by a further six tests. After the last of the series, January 1996, President Chirac declared the French nuclear test programme to be completed. After its test on 29 July 1996 China announced a halt to its testing activity for the first time.

Even though the moratoria did not significantly slow weapon developments they had an influence on public opinion and became a condition for the real test ban negotiations to be finally concluded.

1.11. AN INTERNATIONAL TREATY ON A COMPREHENSIVE BAN ON NUCLEAR TESTING

A ban on nuclear weapon testing was an important disarmament issue for more than 40 years, since tests were a prerequisite for the development of nuclear weapons, and test explosions were seen as a clear expression of the nuclear arms race. Furthermore, the tests spread radioactive materials. India's Prime Minister Nehru put forward a proposal for a ban to the UN in 1954. The treaties and agreements that were later reached, however, only limited the

test activity in various ways, and nuclear weapon development was not slowed down.²

Negotiations on a comprehensive ban on nuclear testing started in January 1994 at the Conference on Disarmament (CD) in Geneva. Because of the generally improved political climate, for the first time the five nuclear weapon states were willing to aim for an all-embracing ban on nuclear weapon tests. The five states reached agreement that the ban should apply to all types of nuclear explosion, even peaceful ones, and even explosions of very low yield.

The Comprehensive Test-Ban-Treaty (CTBT) was signed in September 1996. It consists of 17 articles and a separate protocol on the details of verification.

In Article I the states parties commit themselves not to carry out any nuclear weapon test or any other nuclear explosion and to refrain from participating in the carrying out of any nuclear explosion.

The *CTBT Organization* was established as an independent body with its seat in Vienna (Article II). The Organization includes a Conference, an Executive Council and a Technical Secretariat.

Article IV deals with the verification of the treaty.

An *International Monitoring System (IMS)*, under the authority of the Technical Secretariat, will comprise facilities based on four different technologies: seismological monitoring, hydroacoustic monitoring (to register pressure waves in the world's oceans), infrasound monitoring and the measurement of radioactive particles in the atmosphere. An International Data Centre (IDC), which is an integral part of the Technical Secretariat, is to be responsible for dealing with and compiling the incoming raw data from the monitoring stations and sending out information to the states parties to the treaty.

An important element of the verification regime of the treaty is the right to conduct on-site inspections. If it is the assessment of a state party that information collected by the IMS indicates that a nuclear explosion might have occurred the national authority of that state has the right to request the Executive Council to initiate an on-site inspection.

The treaty is of unlimited duration (Article IX), but as in many other treaties there is a clause stating

² 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (Partial Test Ban Treaty, PTBT); 1974 US–Soviet Treaty on the Limitation of Underground Nuclear Weapon Tests (Threshold Test Ban Treaty, TTBT); and 1976 US–Soviet Treaty on Underground Nuclear Explosions for Peaceful Purposes (Peaceful Nuclear Explosions Treaty, PNET).

that a state party may withdraw if it decides that the treaty jeopardizes its supreme interests.

Article XIV states that the treaty shall enter into force 180 days after the deposit of instruments of ratification by 44 listed CD member states. All countries that according to the IAEA have nuclear reactors are on the list, including India, Israel and Pakistan, the three threshold states.

A test ban does not have the same significance today for the proliferation of nuclear weapons as it would have had if it had been achieved during an earlier stage of nuclear weapon development. With modern technology and economic resources it is now possible for states to produce simple fission devices (however, without being completely certain they will function as intended) without test explosions. Developing hydrogen bombs without testing would be more difficult, however.

A special conference on facilitating the entry into force of the CTBT, in accordance with Article 14.2 of the Treaty, was held in October 1999, but it was not conclusive.

The treaty bans only actual physical explosions, not subcritical tests or computer-simulated tests. This means that even after entry into force of the complete ban, the nuclear powers will be permitted to verify the safety and reliability of their nuclear weapon arsenals. Moreover, in the opinion of experts, the CTBT cannot prevent any state aspiring for nuclear status from constructing, without explosive testing, a small arsenal of fission weapons, and doing so with some degree of certainty that the weapons will perform as envisaged. It is, however, considerably more difficult to develop thermo-nuclear weapons without test explosions.

It is very unlikely that the CTBT will enter into force in the near future. Of the nuclear weapon states France, Russia and the UK have ratified the treaty. However, the US Senate voted against ratification, in October 1999.

The states that have signed the CTBT, however, have in practice renounced nuclear explosions even

before the treaty has become effective. Given the large number of countries approving the CTBT, it is evident that it enjoys strong support in world public opinion. The international monitoring system is partly in operation, and a Preparatory Commission has been established and meets regularly.

155 countries have signed the treaty, but these do not include India, Israel or Pakistan. North Korea is another significant non-signatory of the CTBT—although it is an NPT state party it has been suspected of having nuclear facilities in violation of the treaty. By 1 July 2000, 59 states had ratified the treaty (including 29 of the required 44).

The 44 states whose ratification of the CTBT is required for entry into force are:

Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Congo (Democratic Republic of), Egypt, Finland, France, Germany, Hungary, India, Indonesia, Iran, Israel, Italy, Japan, Korea (North), Korea (South), Mexico, Netherlands, Norway, Pakistan, Peru, Poland, Romania, Russia, Slovakia, South Africa, Spain, Sweden, Switzerland, Turkey, UK, Ukraine, USA and Viet Nam

(States in bold text had ratified the treaty as of 1 July 2000.)

Note:

This Introduction draws extensively on SIPRI Fakta-
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material published in SIPRI Yearbooks since 1990.
It was translated by Billie Bielckus.

2. SUMMARY OF NUCLEAR TESTS, 1945–98

The list includes all nuclear tests (as defined in section 3.1) conducted in nuclear weapon programmes, PNEs and French, Soviet and US (not British) safety experiments, and the two atomic bombs dropped on Japan in 1945.

a = atmospheric (or in a few cases under water); u = underground.

Year	USA ^a		USSR/Russia		UK ^a		France		China		India		Pakistan		Total
	a	u	a	u	a	u	a	u	a	u	a	u	a	u	
1945	3	–	–	–	–	–	–	–	–	–	–	–	–	–	3
1946	2 ^b	–	–	–	–	–	–	–	–	–	–	–	–	–	2
1947	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
1948	3	–	–	–	–	–	–	–	–	–	–	–	–	–	3
1949	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
1950	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
1951	15	1	2	–	–	–	–	–	–	–	–	–	–	–	18
1952	10	–	–	–	1	–	–	–	–	–	–	–	–	–	11
1953	11	–	5	–	2	–	–	–	–	–	–	–	–	–	18
1954	6	–	10	–	–	–	–	–	–	–	–	–	–	–	16
1955	17 ^b	1	6 ^b	–	–	–	–	–	–	–	–	–	–	–	24
1956	18	–	9	–	6	–	–	–	–	–	–	–	–	–	33
1957	27	5	16 ^b	–	7	–	–	–	–	–	–	–	–	–	55
1958	62 ^c	15	34	–	5	–	–	–	–	–	–	–	–	–	116
1959	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0 ^d
1960	–	–	–	–	–	–	3	–	–	–	–	–	–	–	3 ^d
1961	–	10	58 ^b	1	–	–	1	1	–	–	–	–	–	–	71 ^d
1962	39 ^b	57	78	1	–	2	–	1	–	–	–	–	–	–	178
1963 ^e	4	43	–	–	–	–	–	3	–	–	–	–	–	–	50
1964	–	45	–	9	–	2	–	3	1	–	–	–	–	–	60
1965	–	38	–	14	–	1	–	4	1	–	–	–	–	–	58
1966	–	48	–	18	–	–	6	1	3	–	–	–	–	–	76
1967	–	42	–	17	–	–	3	–	2	–	–	–	–	–	64
1968	–	56	–	17	–	–	5	–	1	–	–	–	–	–	79
1969	–	46	–	19	–	–	–	–	1	1	–	–	–	–	67
1970	–	39	–	16	–	–	8	–	1	–	–	–	–	–	64
1971	–	24	–	23	–	–	5	–	1	–	–	–	–	–	53
1972	–	27	–	24	–	–	4	–	2	–	–	–	–	–	57
1973	–	24	–	17	–	–	6	–	1	–	–	–	–	–	48
1974	–	22	–	21	–	1	9	–	1	–	–	1	–	–	55
1975	–	22	–	19	–	–	–	2	–	1	–	–	–	–	44
1976	–	20	–	21	–	1	–	5	3	1	–	–	–	–	51
1977	–	20	–	24	–	–	–	9	1	–	–	–	–	–	54
1978	–	19	–	31	–	2	–	11	2	1	–	–	–	–	66
1979	–	15	–	31	–	1	–	10	1	–	–	–	–	–	58
1980	–	14	–	24	–	3	–	12	1	–	–	–	–	–	54
1981	–	16	–	21	–	1	–	12	–	–	–	–	–	–	50
1982	–	18	–	19	–	1	–	10	–	1	–	–	–	–	49
1983	–	18	–	25	–	1	–	9	–	2	–	–	–	–	55
1984	–	18	–	27	–	2	–	8	–	2	–	–	–	–	57
1985	–	17	–	10	–	1	–	8	–	–	–	–	–	–	36 ^f
1986	–	14	–	–	–	1	–	8	–	–	–	–	–	–	23 ^f
1987	–	14	–	23	–	1	–	8	–	1	–	–	–	–	47 ^f
1988	–	15	–	16	–	–	–	8	–	1	–	–	–	–	40
1989	–	11	–	7	–	1	–	9	–	–	–	–	–	–	28
1990	–	8	–	1	–	1	–	6	–	2	–	–	–	–	18

Year	USA ^a		USSR/Russia		UK ^a		France		China		India		Pakistan		Total
	a	u	a	u	a	u	a	u	a	u	a	u	a	u	
1991	-	7	-	-	-	1	-	6	-	-	-	-	-	-	14
1992	-	6	-	-	-	-	-	-	-	2	-	-	-	-	8 ^g
1993	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1 ^g
1994	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2 ^g
1995	-	-	-	-	-	-	-	5	-	2	-	-	-	-	7 ^g
1996	-	-	-	-	-	-	-	1	-	2	-	-	-	-	3
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
1998	-	-	-	-	-	-	-	-	-	-	-	2	-	2	4
Subtotal	217	815	219	496	21	24	50	160	23	22	-	3	-	2 2	052
Total	1 032		715		45		210		45		3		2	2 052	

^a All British tests from 1962 were conducted jointly with the USA at the Nevada Test Site, so the number of US tests is actually higher than indicated here. The British Labour Government observed a unilateral moratorium on testing in 1965-74.

^b One of these tests was carried out under water.

^c Two of these tests were carried out under water.

^d The UK, the USA and the USSR observed a moratorium on testing in the period Nov. 1958-Sep. 1961.

^e On 5 Aug. 1963 the USA, the USSR and the UK signed the Partial Test Ban Treaty (PTBT), prohibiting nuclear explosions in the atmosphere, in outer space and under water.

^f The USSR observed a unilateral moratorium on testing in the period Aug. 1985-Feb. 1987.

^g The USSR observed a moratorium on testing from Jan. 1991 and the USA from Oct. 1992; France observed a moratorium in the period Apr. 1992-Sep. 1995.

Source: Ferm, R., 'Nuclear explosions, 1945-98', *SIPRI Yearbook 1999: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 1999), pp. 562-63.

3. INTRODUCTION TO THE DATA ON NUCLEAR EXPLOSIONS

3.1. DEFINITIONS

The list provides details of all nuclear explosions, including those conducted in nuclear weapon test programmes, explosions carried out for peaceful purposes (PNEs) and the two atomic bombs dropped on Hiroshima and Nagasaki in 1945. Safety experiments, irrespective of whether they caused a nuclear explosion or not, carried out by the USA, the Soviet Union and France (not the UK), are also included.

The yield of the explosions is estimated in kilotons (kt). One kiloton is the explosive yield of a nuclear device equivalent to 1000 tonnes of trinitrotoluene (TNT) high explosive.

Simultaneous underground detonations, sometimes called salvo explosions, were carried out both by the USA (1963–92) and the Soviet Union (1965–90).

In defining an underground nuclear test the definition of the 1990 Protocol to the 1974 US–Soviet Threshold Test Ban Treaty (TTBT, section I, para. 2) is used, which states that a test is ‘either a single nuclear explosion conducted at a test site, or two or more nuclear explosions conducted at a test site within an area delineated by a circle having a diameter of two kilometres and conducted within a total period of time of 0.1 second’. (For the Indian detonations on 11 May 1998 the precise data to determine whether they should be counted as one or two tests according to the TTBT definition are not yet available. On the basis of available information one test is listed in the table. The explosions announced by India on 13 May 1998 are also counted as one test, as are Pakistan’s five explosions on 28 May 1998.)

For the PNEs, the definition in the 1976 Peaceful Nuclear Explosions Treaty (PNET, Article II.a) is used: a PNE is ‘any individual or group underground nuclear explosion for peaceful purposes’. A ‘group explosion’ is defined as ‘two or more individual explosions for which the time interval between successive individual explosions does not exceed five seconds and for which the emplacement points of all explosives can be interconnected by straight line segments, each of which joins two emplacement points and each of which does not exceed 40 kilometres’.

Note: It is not possible to give consistent information on the tests of the respective states as the amount of details given by the sources varies. Thus, the US Department of Energy (DOE) provides more information, for example, on accidental releases of radioactivity, than do the official Russian and French authorities. China has published no information on its testing programme.

3.2. KEY TO DATA

0 or blank = Data not available, nil or negligible figure

The columns

Date is expressed as year, month and day of the month. The date listed is the Greenwich Mean Time (GMT) date for the explosion.

Origin time for the explosion is expressed as GMT: hour, minute, second and tenth of a second.

ID no. Identification number. Each explosion has its own unique identification number. It can be used for searching footnotes.

Country lists the state that carried out the explosion.

Region gives the name of the test site and/or the geographical region where the explosion was conducted.

Abbreviations:

AK	Alaska
ALG	Algeria
ARK	Arkhangelsk region
AUSTR	Australia
CO	Colorado
FALLON	Naval Air Station, Fallon, Nevada
IS	island
KAZAKH	Kazakhstan
KRASNO	Krasnoyarsk territory
MANGY	Mangyshlak
MARALI	Maralinga
MONTEB	Montebello
MS	Mississippi
MTR	Missile Testing Range (near Kapustin Yar, Astrakhan region, Russia).
MURM	Murmansk
NELLIS	Nellis Air Force Range, Nevada
NM	New Mexico
NTS	Nevada Test Site
NV	Nevada
NZ	Novaya Zemlya (Northern Test Site, in the Arctic Ocean, Russia)
RUSS	Russia
SEMI	Semipalatinsk test site (in east Kazakhstan)
STAVRO	Stavropol territory (Russia)
TURKMEN	Turkmenistan
UZBEK	Uzbekistan
V	Valley

Other names are also slightly abbreviated, but since they are easily recognizable they are not listed above.

Sou indicates source: One reliable source reporting the explosion is given for each event. However, the information given for most explosions listed in the table is compiled by reports from more than one source. For the sources and their codes, see section 2.3.

Lat and *Long* indicate latitude and longitude: the geographical coordinates for the place where the explosion was conducted. The location is often approximate. A negative latitude indicates south and a negative longitude indicates west.

mb and *Ms* indicate the body wave magnitude and the surface wave magnitude of the events as reported by the given source.

Depth estimates show, in kilometres, how deep in the ground the explosions were conducted. Some height estimates are also given to indicate the altitude at which atmospheric tests were conducted. A positive figure indicates depth, a negative figure indicates height.

Yield indicates the range of yield. For most explosions lower (l) and upper (u) yield estimates are given. If an exact yield is available the upper figure and lower figure are the same. Unless otherwise noted in the footnotes, for salvo explosions the yield estimate indicates the yield of each detonation in a test or a peaceful nuclear explosion.

Purpose

COMBAT = The two atomic bombs dropped over Hiroshima and Nagasaki in August 1945.

FMS (used for Soviet tests) = To study the phenomena of a nuclear explosion.

ME = Test conducted in the context of a military exercise with a real nuclear detonation. One such test (Soviet) was conducted, in 1954.

PNE = Peaceful nuclear explosion. The US PNEs were either in the Plowshare Programme (PNE:PLO) or Vela Uniform Tests (PNE:V). The Soviet PNEs include both industrial peaceful explosions and testing of PNE technologies as well as testing of industrial nuclear charges for use in peaceful activities.

SAM (used for Soviet tests) = Tests to study accidental modes and emergencies.

SE (used for French and US tests) = Tests to determine the safety of nuclear weapons in case of accident.

TRANSP = Transportation-storage purposes. (Four US tests conducted at Nellis Air Force Range in 1963.)

WE (used for British, French and US tests) = To evaluate the effects of a nuclear detonation on various targets.

WR = Weapons-related, i.e. related to the weapon development programme. (N.B. If no information on the purpose of a test is available WR is given in the table.)

Name gives the name of the event. Longer names are shortened and in some cases where the abbreviation cannot be readily interpreted the full name is given in a footnote.

Type refers to the method of deployment of the nuclear device:

There are two categories: atmospheric (ATMOSPH) and underground (UG). When no further details are available, only ATMOSPH or UG is given in the table.

When atmospheric explosions were conducted the device was dropped from a balloon (BALLOON) or an aircraft (AIRDROP), launched by a rocket (ROCKET), mounted at the top of a steel or wooden tower (TOWER), placed on a boat (BARGE), on the surface of the sea (WATERSURFACE), on the ground close to the earth's surface (SURFACE) or in a crater (CRATER). A few nuclear tests were conducted under water (UW).

Underground explosions were either conducted at the bottom of drilled or mined vertical holes or shafts (SHAFT) or in horizontal tunnels (TUNNEL or GALLERY) drilled into a mountain or mesa in a way that places the burst point deep within the earth. One Soviet PNE was conducted in a mine (MINE).

French underground tests in Polynesia were either conducted in wells in the ground (SHAFT/G) or in drilled holes in the lagoon of the atoll (SHAFT/LG).

F-column

'F' indicates that a footnote is available. The footnote can be retrieved by the date and the ID number. A figure (sometimes without a preceding 'F') means that the event is a salvo explosion. The figure corresponds to the number of detonations, each having the same yield in the reported yield range.

Note: Unless otherwise noted in the footnotes, all tests at the Nevada Test Site or at the Nellis Air Force Range before 15 September 1961 produced radioactivity detected off-site. (All these tests were atmospheric.) Unless otherwise noted in footnotes, no test at these test sites on or after that date—all underground—released radioactivity that was detected off-site. The other established nuclear weapon states have not published information on releases of radioactivity. (See note in section 3.1 above.)

3.3. SOURCES

- BKY: Berkeley Seismological Laboratory, Berkeley, CA, USA.
- DIS: Dahlman, O. and Israelson, H., National Defense Research Institute (FOA), Stockholm, *Monitoring Underground Nuclear Explosions* (Elsevier: Amsterdam, 1977).
- DOE: US Department of Energy (DOE), various news bulletins and *United States Nuclear Tests: July 1945 through September 1992*, DOE/NV-209 (Rev. 14) (DOE: Washington, DC, 1994).
- HFS: Hagfors Observatory, Sweden, operated by the *Defence Research Establishment* (FOA). Various reports.
- IDC: Prototype International Data Center, Washington, DC (Arlington, Va.), *Nuclear Explosion Data Base*.
- ISC: Bulletin of the International Seismological Centre, (Thatcham, UK).
- MTM: Ministry of the Russian Federation for Atomic Energy and Ministry of Defense of the Russian Federation, *USSR Nuclear Weapons Tests and Peaceful Nuclear Explosions, 1949 through 1990* (Russian Federal Nuclear Center—All-Russian Research Institute of Experimental Physics [VNIIEF]: Sarov, 1996).
- NOA: Norwegian Seismic Array, NORSAR, Kjeller, Norway. Various reports and information.
- NRD: Norris, R. S., Burrows, A. S. and Fieldhouse, R. W., 'British, French and Chinese nuclear weapons', *Nuclear Weapons Databook, Vol. V* (Natural Resources Defense Council [NRDC]: Washington, DC, 1994).
- SPA: Direction des centres d'experimentations nucléaires [DIRCEN] and Commissariat à l'Energie Atomique [CEA], *Assessment of French nuclear testing* (DIRCEN and CEA: Paris, 1998).
- UGS: US Geological Survey, National Earthquake Information Center, *Preliminary determination of epicenters*.
- WTN: Department of Scientific and Industrial Research, Geology and Geophysics Division, Wellington, New Zealand. Various reports and information..
- ZAR: Zander, I. and Araskog, R., *Nuclear explosions 1945-72*, FOA 4 Report, A 4505-A1 (FOA: Stockholm, 1973).

4. DATA ON NUCLEAR EXPLOSIONS, 1945-98

Table with columns for ID, values, country, name, type, weight, cost, and location. It lists various equipment and materials with their respective specifications.

950817	5957.7	95002	CHINA	LOP NOR	HFS	41.559	88.800	6.4	0.0	0.000	40.0	160.0	WR		UG
950905	212958.4	95003	FRANCE	MURUROA	WTN	-21.852	-138.844	0.0	0.0	0.000	0.0	20.0	WR	TETHYS	UG
951001	232957.9	95004	FRANCE	FANGATAUFA	WTN	-22.250	-138.745	0.0	0.0	0.000	0.0	110.0	WR	PLOUTOS	UG
951027	215958.1	95005	FRANCE	MURUROA	WTN	-21.891	-138.983	0.0	0.0	0.000	0.0	60.0	WR	AEPYTOS	UG
951121	212958.0	95006	FRANCE	MURUROA	WTN	-21.879	-139.032	0.0	0.0	0.000	0.0	40.0	WR	PHEGEE	UG
951227	212958.0	95007	FRANCE	MURUROA	WTN	-21.881	-138.973	0.0	0.0	0.000	0.0	30.0	WR	THEMISTO	UG
960127	212957.7	96001	FRANCE	FANGATAUFA	WTN	-22.236	-138.815	0.0	0.0	0.000	0.0	120.0	WR	XOUTHOS	UG
960608	25559.4	96002	CHINA	LOP NOR	HFS	41.650	88.760	6.3	0.0	0.000	30.0	120.0	WR		UG
960729	14859.1	96003	CHINA	LOP NOR	HFS	41.690	88.350	5.3	0.0	0.000	3.0	12.0	WR		UG
980511	101344.0	98001	INDIA	POKHRAN	HFS	27.070	71.700	5.3	0.0	0.000	0.0	20.0	WR	SHAKTI 1-3	UG
980513	65100.0	98003	INDIA	POKHRAN	NRD	27.070	71.700	0.0	0.0	0.000	0.0	1.0	WR		UG
980528	101617.6	98004	PAKIST	CHAGAI	HFS	28.900	64.890	0.0	0.0	0.000	0.0	35.0	WR		UG
980530	65457.1	98005	PAKIST	KHARAN	HFS	28.490	63.780	5.0	0.0	0.000	0.0	18.0	WR		UG

Appendix 1. Footnotes—USA

For the salvo explosions: unless otherwise noted in the footnotes the yield estimate indicates the yield of each explosion. Unless otherwise noted, all tests at the NTS or the Nellis Air Force Range before 15 September 1961 produced radioactivity detected off-site. Unless otherwise noted, no test on or after that date had a release of radioactivity that was detected off-site.

Date	ID no.	Text
510508	51008	First thermonuclear explosion.
570919	57039	First detonation contained underground.
611210	61068	First peaceful nuclear explosion (PNE), Plowshare Program. Multiple-purpose experiment in salt. Accidental release of radioactivity detected off-site.
610915	61017	Accidental release of radioactivity detected off-site.
611210	61068	Accidental release of radioactivity detected off-site.
611222	61071	Accidental release of radioactivity detected off-site.
620301	62012	Joint US–British test. Accidental release of radioactivity detected off-site.
620305	62913	Accidental release of radioactivity detected off-site.
620421	62023	Accidental release of radioactivity detected off-site.
620519	62040	Accidental release of radioactivity detected off-site.
620613	62051	Accidental release of radioactivity detected off-site.
620706	62062	Excavation experiment. Thermonuclear device. Release of radioactivity detected off-site.
620711	62067	Release of radioactivity detected off-site.
620714	62069	Release of radioactivity detected off-site.
620717	62070	Release of radioactivity detected off-site.
621019	62123	Accidental release of radioactivity detected off-site.
630515	63043	Release of radioactivity detected off-site.
630525	63044	Release of radioactivity detected off-site.
630605	63023	Operational release of radioactivity detected off-site.
630609	63046	Last US atmospheric test. Radioactivity detected off-site.
631212	63042	Accidental release of radioactivity detected off-site.
640123	64002	Operational release of radioactivity detected off-site.
640313	64005	Accidental release of radioactivity detected off-site.
641009	64030	Isotope production and explosive development.
641105	64036	Effects of contained explosion in carbonate rock.
641205	64040	Drill (Source-Lower): 3.4 kt; Drill (Target-Upper): < 20kt. Accidental release of radioactivity detected off-site.
641216	64041	Accidental release of radioactivity detected off-site.
641218	64043	Excavation test of explosive buried at greater depth in relation to yield. Release of radioactivity detected off-site.
650212	65005	Accidental release of radioactivity detected off-site.
650414	65016	Release of radioactivity detected off-site.
650507	65019	Accidental release of radioactivity detected off-site.
650616	65029	Accidental release of radioactivity detected off-site.
660305	66008	Accidental release of radioactivity detected off-site.
660324	66013	Excavation device experiment.
660425	66019	Accidental release of radioactivity detected off-site.
660615	66032	Accidental release of radioactivity detected off-site.
660728	66039	Excavation device experiment.
660912	66045	Accidental release of radioactivity detected off-site.
661105	66054	Excavation device experiment.
670119	67001	Accidental release of radioactivity detected off-site.
670622	67020	Excavation device experiment.

670626	67021	Controlled release of radioactivity detected off-site.
670629	67024	Accidental release of radioactivity detected off-site.
670831	67031	Accidental release of radioactivity detected off-site.
670921	67034	Emplacement technique experiment.
671210	67045	Joint government/industry gas stimulation experiment.
680118	68002	Accidental release of radioactivity detected off-site.
680126	68005	Release of radioactivity detected off-site.
680410	68016	Noor: 20–200 kt, Throw: <20 kt.
680917	68042	Excavation device experiment.
681208	68052	Release of radioactivity detected off-site.
690910	69023	Joint Government/industry gas stimulation experiment. Operational release of radioactivity detected off-site.
691029	69035	The yield figure given in the table is the total yield of all four explosions. Accidental release of radioactivity detected off-site.
700306	70011	Arabis-Red and Arabis-Green were weapons-related (WR) explosions, Arabis-Blue was a safety experiment (SE).
700505	70020	Controlled release of radioactivity detected off-site.
700526	70028	Flask-Yellow: 105 kt; Flask-Yellow and Flask-Red: 20 kt each.
701013	70056	Scree-Acajou and Scree-Alhambra were Weapons Related (WR), Scree-Chamois was a Safety Experiment (SE).
701028	70057	Truchas-Chacon and Truchas-Chamisal were Safety Experiments (SE), Truchas-Rodarte was a weapons related (WR) test.
701218	70051	Accidental release of radioactivity detected off-site.
720809	72049	Cebolia and Cuchillo were weapons related (WR) explosions, Solano was a safety experiment (SE).
721221	72056	Flax-Test: 20–200 kt, Flax-Backup: <20 kt.
730517	73006	Joint government/industry gas stimulation experiment. Last US peaceful nuclear explosion (PNE), Plowshare Program.
750206	75036	Portola and Portala-Larkin.
770816	77043	Gruyère and Gruyère-Gradino.
780510	78060	The Transom device was destroyed by the 5 Sep. 1979 detonation (Hearts).
790906	79033	The detonation destroyed the 10 May 1978 device (Transom) which had not detonated.
850406	85005	Controlled release of radioactivity detected off-site.
860322	86001	Operational release of radioactivity detected off-site.
880622	88016	The test was conducted simultaneously with the Nightingale safety experiment (SE).
880622	88042	The experiment was conducted simultaneously with the Rhyolite weapons related (WR) test.
880817	88019	The test was conducted in the presence of a team of Soviet scientists in accordance with the US-Soviet May/June 1988 Joint Verification Experiment (JVE) Agreement.
910914	91011	Verification test under the provisions of the 1990 Protocol to the 1974 Threshold Test Ban Treaty (TTBT).

Appendix 2. Footnotes—USSR

Date	ID no.	Text
530812	53012	First Soviet thermonuclear explosion.
611011	61039	First Soviet underground test.
621225	62177	Last Soviet atmospheric test.
650115	65002	First peaceful nuclear explosion (PNE); excavation explosion.
660422	66063	First use of nuclear explosion to form rock salt cavities.
660930	66049	First use of nuclear explosion to close gas plume boreholes.
671021	67039	One explosion of 20–150 kt, one of 150–1500 kt.
680820	68047	One SE of <0.001 kt, one WR explosion of 0.001–20 kt.
681107	68047	One explosion of <0.001 kt, two of 150–1500 kt each.
691014	69033	One explosion of 20–150 kt, two of 150–1500 kt each.

700625	70031	First use of nuclear explosion to create reservoirs for gas storage.
720328	72005	One SAM explosion of <0.001 kt, one WR explosion of 0.001–20 kt, one PNE of 0.001–20 kt.
720828	72005	One explosion of 20–150 kt, three of 150–1500 each.
720904	72024	First use of nuclear explosion for testing of ore-crushing technology.
721210	72032	One explosion of 0.001–20 kt, one of 20–150 kt.
730710	70015	Two WR explosions of 0.001–20 kt each, one SAM explosion of <0.001 kt.
730710	73015	Two WR explosions of 0.001–20 kt each, one SAM explosion of <0.001 kt.
730912	73023	Three explosions of 150–1500 kt each, one of 1500–10 000 kt.
731026	73029	First use of nuclear explosion for burial of petro-chemical industrial waste.
740829	74028	One explosion of 0.001–20 kt, one of 20–150 kt, three of 150–1500 kt each.
750823	75019	Four WE explosions: two of 0.001–20 kt each, two of 150–1500 kt each; four WR explosions: two of 20–150 kt each, two of 150–1500 kt each.
751021	75024	One explosion of 20–150 kt, four of 150–1500 kt each.
761020	76030	One SAM explosion of <0.001 kt, two WR explosions of 0.001–20 kt each, one FMS explosion of 0.001–20 kt.
761207	76036	One explosion of 0.001–20 kt, one of 20–150 kt.
770329	77046	One SAM explosion of <0.001 kt, two WR explosions of 0.001–20 kt each.
770901	77018	Three explosions of 0.001–20 kt each, one of 20–150 kt.
770905	77019	One FMS explosion of 0.001–20 kt, one WR explosion of 20–150 kt.
771130	77034	One explosion of 0.001–20 kt, one of 20–150 kt.
771226	77054	One explosion of <0.001 kt, three of 0.001–20 kt each.
780728	78020	Four explosions of 0.001–20 kt each, one of 20–150 kt.
780810	78022	One FMS explosion of 0.001–20 kt; four WR explosions of 0.001–20 kt each, one of 20–150 kt.
780829	78024	One SAM explosion of <0.001 kt, two WR explosions of 0.001–20 kt each.
780927	78031	One SE of <0.001 kt; five WR explosions of 0.001–20 kt each, one of 20–150 kt.
781017	78037	One explosion of 0.001–20 kt, one of 20–150 kt.
781104	78042	One explosion of 0.001–20 kt, one of 20–150 kt.
781129	78044	One explosion of 0.001–20 kt, one of 20–150 kt.
790117	79002	One explosion of 0.001–20 kt, one of 20–150 kt. Total energy release: 65 kt.
790707	79022	One explosion of 0.001–20 kt, one of 20–150 kt.
790714	79023	Total energy release: 21 kt.
790804	79028	One explosion of 0.001–20 kt, one of 20–150 kt.
790818	79031	One explosion of 0.001–20 kt, one of 20–150 kt.
790924	79038	Two explosions of 0.001–20 kt each, one of 20–150 kt.
791018	79044	Two explosions of 0.001–20 kt each, two of 20–150 kt each.
791024	79045	One explosion of 0.001–20 kt, one of 20–150 kt. Total energy release: 33 kt.
791028	79046	One explosion of 0.001–20 kt, one of 20–150 kt.
791202	79050	One WR explosion of 0.001–20 kt, one FMS explosion of 20–150 kt.
791223	79053	One explosion of 0.001–20 kt, one of 20–150 kt.
800629	80021	Two explosions of 0.001–20 kt each, one of 20–150 kt.
801011	80036	Five explosions of 0.001–20 kt each, two of 20–150 kt each.
801214	80046	Two explosions of 0.001–20 kt each, one of 20–150 kt.
801227	80049	One explosion of 0.001–20 kt, one of 20–150 kt.
810329	81007	One WR explosion, two FMS explosions.
810422	81009	Two explosions of 0.001–20 each, one of 20–150 kt.
811001	81035	Three explosions of 0.001–20 kt each, one of 20–150 kt.
811018	81037	One WR explosion of 0.001–20 kt, one of 20–150 kt.
820625	82014	One WE explosion of 0.001–20 kt, one WR explosion of 0.001–20 kt.
820704	82016	Two explosions of 0.001–20 kt, one of 20–150 kt.

821011	82041	Three explosions of 0.001–20 kt each, one of 20–150 kt.
821205	82051	One explosion of 0.001–20 kt, one of 0.001–20 kt.
821226	82054	One FMS explosion of 20–150 kt, one WR explosion of 20–150 kt.
830530	83014	One FMS explosion of 0.001–20 kt, one WR explosion of 0.001–20 kt.
830612	83016	One explosion of 0.001–20 kt, one of 20–150 kt.
830818	83027	Three WR explosions: two of 0.001–20 kt each, one of 20–150 kt; one PNE of 0.001–20 kt; one SAM explosion of 0.001–20 kt.
830925	83039	Three WR explosions: two of 0.001–20 kt each, one of 20–150 kt; one WR explosion of 0.001–20 kt.
831006	83040	One explosion of 0.001–20 kt, one of 20–150 kt.
840415	84008	One explosion of 0.001–20 kt, one of 20–150 kt.
840425	84009	One explosion of 0.001–20 kt, one of 20–150 kt.
840526	84015	One explosion of 0.001–20 kt, one of 20–150 kt.
840714	84022	One explosion of 0.001–20 kt, one of 20–150 kt.
841025	84039	Three explosions of 0.001–20 kt each, one of 20–150 kt.
841123	84046	Three explosions of 0.001–20 kt each.
841202	84047	One FMS of 0.001–20 kt, one WR explosion of 20–150 kt,
841216	84051	One explosion of 0.001–20 kt, one of 20–150 kt.
841228	84053	One PNE of 0.001–20 kt, one WR explosion of 20–150 kt.
850210	85001	Two explosions of 0.001–20 kt each, one of 20–150 kt.
850615	85014	One explosion of 20–150 kt, two of 0.001–20 kt.
850630	85016	One explosion of 0.001–20 kt, one of 20–150 kt.
850725	85019	Two WR explosions of 0.001–20 kt each, two SAM explosions of 0.001–20 kt each.
870312	87004	Two explosions of 0.001–20 kt each.
870403	87048	Three explosions of 0.001–20 kt each.
870417	87007	Two explosions of 0.001–20 kt each, one of 20–150 kt.
870620	87020	One explosion of 0.001–20 kt, one of 20–150 kt.
870802	87028	One explosion of 0.001–20 kt, two of 20–150 kt each.
870802	87029	Three WR explosions: two of 0.001–20 kt each, one of 20–150 kt; one FMS explosion of 0.001–20 kt; one SAM explosion of 0.001–20 kt.
870918	87033	One WE explosion of 0.001–20 kt, one SAM explosion of 0.001–20 kt.
871115	87040	One explosion of 0.001–20 kt, one of 20–150 kt.
871213	87044	One explosion of 0.001–20 kt, one of 20–150 kt.
871227	87046	One explosion of 0.001–20 kt, one of 20–150 kt.
880206	88001	Two SAM explosions of <0.001 kt each, one WR explosion of 0.001–20 kt.
880213	88002	One explosion of 0.001–20 kt, one of 20–150 kt.
880507	88008	Two explosions of 0.001–20 kt each, one of 20–150 kt.
880914	88023	The test was conducted in the presence of a team of Soviet scientists in accordance with the US–Soviet May/June 1988 Joint Verification Experiment (JVE) Agreement.
881123	88031	One SAM explosion of <0.001 kt, one FMS explosion of 0.001–20 kt, one WR explosion of 0.001–20 kt.
881204	88034	One SAM explosion of <0.001 kt; one WE explosion of 0.001–20 kt; three WR explosions: two of 0.001–20 kt each, one of 20–150 kt.
881217	88036	One explosion of 0.001–20 kt, one of 20–150 kt
890122	89001	One explosion of 0.001–20 kt, one of 20–150 kt.
891019	89019	Two explosions of 0.001–20 kt each, one of 20–150 kt.
901024	90013	Seven WR explosions: two of <0.001 kt each, four of 0.001–20 kt each, one of 20–150 kt; one SAM explosion of <0.001 kt.

Appendix 3. Footnotes—UK

Date	ID no.	Text
531014	53017	Widespread contamination especially over aboriginal community.
560619	56016	Radioactive dust spread over parts of northern Australia.
580428	58017	First British two-stage thermonuclear test.
580923	58062	Last British atmospheric test.
620301	62012	First British underground test, first joint British-US test at the Nevada Test Site. Accidental release of radioactivity detected off site.

Appendix 4. Footnotes—France

Date	ID no.	Text
611107	61066	First French underground test.
620501	62027	Accidental release of radioactive gases resulted in the contamination of 12 soldiers.
680824	68035	First French thermonuclear explosion. The yield was >1000 kt.
680908	68040	The yield of the explosion was >1000 kt.
710612	71007	Fallout spread over the Tureia atoll.
740707	74016	Last French atmospheric test.
750605	75013	France's first underground test at its test centre in French Polynesia (Centre d'Experimentation du Pacifique, CEP).
790725	79025	The detonation caused a massive layer of limestone and coral to break off the edge of the atoll. The material fell into the lagoon and produced a large wave which washed over the atoll.
820627	82059	The test was observed by a scientific mission led by vulcanologist Haroun Tazieff. The team took air and water samples during the test to verify safety arrangements.

Appendix 5. Footnotes—China

Date	ID no.	Text
661228	66062	Two-stage hydrogen bomb principles test. Reduced amounts of fission materials and thermonuclear materials were used.
670617	67019	First Chinese full-yield, two-stage thermonuclear test.
690922	69027	China's first underground test.
761117	76033	Largest Chinese test. Fallout resulted on the USA.
801016	80038	Last atmospheric test conducted by any nuclear state.

Appendix 6. Footnotes—India

Date	ID no.	Text
980511	98001	India announced one 43 kt device, one 12 kt device and one 0.2 kt device. International seismological experts suggested a combined yield of not more than 25 kt. Precise data to determine whether the detonations should be counted as one or two tests, according to the TTBT definition (see 2. Introduction to the list of nuclear explosions, 2.1. Definitions), are not available. On the basis of available information one test is listed.
980513	98002	Two explosions were announced, with yields of 0.2 and 0.6 kt, respectively. No signals were recorded by seismological stations outside India. The explosions are listed as one test.

Appendix 7. Footnotes—Pakistan

Date	ID no.	Text
980528	98004	Five explosions were announced. According to Pakistani scientists the yield of the largest explosion was 30–35 kt. The other four explosions were of low yield and their aggregate yield was 40–45 kt. Stations in the region, but outside Pakistan, suggested 10 kt. The explosions are listed as one test.
980530	98005	The yield of the explosion was announced to be 15–18 kt, but averaging the reports from more than 50 non-Pakistani seismological stations indicated a body wave magnitude of 4.3 kt, corresponding to a yield of 2–8 kt.