Chapter 1

Executive Summary

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The chances of an accidental release of radioactive material have been made as remote as possible. Public concerns about safety are fueled by concerns about the testing program in general and exacerbated by the government's policy of not announcing all tests.

INTRODUCTION

During a nuclear explosion, billions of atoms release their energy within a millionth of a second, pressures reach several million pounds per square inch, and temperatures are as high as one-million degrees centigrade. A variety of radioactive elements are produced depending on the design of the explosive device and the contribution of fission and fusion to the explosion. The half-lives of the elements produced range from less than a second to more than a million years.

Each year over a dozen nuclear weapons are detonated underground at the Nevada Test Site.[1] The tests are used to develop new nuclear weapons and to assess the effects of nuclear explosions on military systems and other hardware. Each test is designed to prevent the release of radioactive material. The objective of each test is to obtain the desired experimental information and yet successfully contain the explosion underground (i.e., prevent radioactive material from reaching the atmosphere).

HOW SAFE IS SAFE ENOUGH?

Deciding whether the testing program is safe requires a judgment of how safe is safe enough. The subjective nature of this judgment is illustrated through the decision-making process of the Containment Evaluation Panel (CEP) which reviews and assesses the containment of each test.[2] The panel evaluates the probability of containment using the terms "high confidence," ''adequate degree of confidence, ' and ''some doubt. " But the Containment Evaluation Panel has no guidelines that attempt to quantify or describe in probabilistic terms what constitutes for example, an "adequate degree of confidence." Obviously, there can never be 100 percent confidence that a test will not release radioactive material. Whether ''adequate confidence" translates into a chance of 1 in 100, 1 in 1,000, or 1 in 1,000,000, requires a decision about what is an acceptable level of risk. In turn, decisions of acceptable level of risk can only be made by weighing the costs of an unintentional release against the benefits of testing. Consequently, those who feel that testing is important for our national security will accept greater risk, and those who oppose nuclear testing will find even small risks unacceptable.

Establishing an acceptable level of risk is difficult, not only because of the value judgments associated with nuclear testing, but also because the risk is not seen as voluntary by those outside the testing program. A public that readily accepts the risks associated with voluntary activities—such as skydiving or smoking—may still consider the much lower risks associated with nuclear testing unacceptable.

HOW SAFE HAS IT BEEN?

Some insight into the safety of the nuclear testing program can be obtained by reviewing **the** containment record. Releases of radioactive material are categorized with terms that describe both the volume **of material** released and the conditions of the release:

[1] Currently, all U.S. nuclear test explosions are conducted at the Nevada Test Site.

[2] The Containment Evaluation Panel is a group of representatives from various laboratories and technical consulting organizations who evaluate the proposed containment plan for each test without regard to cost or other outside considerations (see ch. 2 for a complete discussion).

Containment Failures: Containment failures are unintentional releases of radioactive material to the atmosphere due to a failure of the containment system. They are termed "ventings," if they are prompt, massive releases; or "seeps," if they are slow, small releases that occur soon after the test.

Late-Time Seeps: Late-time seeps are small releases that occur days or weeks after a test when gases diffuse through pore spaces of the overlying rock and are drawn to the surface by decreases in atmospheric pressure.

Controlled Tunnel Purging: A controlled tunnel purging is an intentional release to allow either recovery of experimental data and equipment or reuse of part of the tunnel system.

Operational Release: Operational releases are small, consequential releases that occur when core or gas samples are collected, or when the drill-back hole is sealed.

The containment record can be presented in different ways depending on which categories of releases are included. **Reports of total numbers of releases are often incomplete because they include only announced tests or releases due to containment failure. The** upper portion of table 1-1 includes **every** instance (for both announced and unannounced tests) where radioactive material has reached the atmosphere **under any circumstances whatsoever since** the 1970 Baneberry test.

Table I-l-Releases From Underground Tests
(normalized to 12 hours after event)

All releases 1971 -1988:	
Containment Failures:	
Camphor, 1971[b]	360 Ci
Diagonal Line, 1971	6,800
Riola, 1980	3,100
Agrini, 1984	690
Late-time Seeps:	
Kappeli, 1984	12
Tierra, 1984	600
Labquark, 1986	20
Bodie, 1986[c]	52
Controlled Tunnel Purgings:	
Hybla Fair, 1974	500
Hybla Gold, 1977	0.005
Miners Iron, 1980	0.3
Huron Landing, 1982	280
Mini Jade, 1983	1
Mill Yard, 1985	5.9
Diamond Beech,1985	1.1
Misty Rain, 1985	63
Mighty Oak, 1986	36,000
Mission Ghost, 1987[c]	3
Operational Releases:	
108 tests from 1970-1988d	5,500
Total since Baneberry:	54,000 Ci
Major pre-1971 releases:	
Platte, 1962	1,900,000 Ci
Eel, 1962	1,900,000
Des Moines, 1962	11,000,000
Baneberry, 1970	6,700,000
26 others from 1958-1970	3,800,000
Total:	25,300,000 Ci
Other Releases for Reference	
NTS Atmospheric Testing 1951-1963:	12,000,000,000 Ci
1 Kiloton Aboveground Explosion:	10,000,000
Chernobyl (estimate):	81 ,000,000

[a]R+12 values apply only to containment failures, others are at time of release.
[b]The Camphor failure includes 140 Ci from tunnel purging.
[c]Bodie and Mission Ghost also had drill-back releases.
[d]Many of these operational releases are associated with tests that were not announced.

SOURCE: Office of Technology Assessment, 1989.

Since 1970, 126 tests have resulted in radioactive material reaching the atmosphere with a total release of about 54,000 Curies (Ci). Of this amount, 11,500 Ci were due to containment failure and late-time seeps. The remaining 42,500 Ci were operational releases and controlled tunnel purgings-with Mighty Oak (36,000 Ci) as the main source. The lower portion of the table shows that the release of radioactive material from underground nuclear testing since Baneberry (54,000 Ci) is extremely small in comparison to the amount of material released by pre-Baneberry underground tests (25,300,000 Ci), the early atmospheric tests at the Nevada Test Site (12,000,000,000 Ci), or even the amount that would be released by a single l-kiloton explosion conducted aboveground (10,000,000 Ci).

From the perspective of human health risk:

If the same person had been standing at the boundary of the Nevada Test Site in the area of maximum concentration of radioactivity for every test since Baneberry (1970), that

person's total exposure would be equivalent to 32 extra minutes of normal background exposure (or the equivalent of 1/1000 of a single chest x-ray).

A worst-case scenario for a catastrophic accident at the test site would be the prompt, massive venting of a 150-kiloton test (the largest allowed under the 1974 Threshold Test Ban Treaty). The release would be in the range of 1 to 10 percent of the total radiation generated by the explosion (compared to 6 percent released by the Baneberry test or an estimated 10 percent that would be released by a test conducted in a hole open to the surface). Such an accident would be comparable to a 15-kiloton **above--ground** test, and would release approximately 150,000,000 Ci. Although such an accident would be considered a major catastrophe today, during the early years at the Nevada Test Site 25 **aboveground** tests had individual yields equal to or greater than 15 kilotons.

SPECIFIC CONCERNS

Recently, several specific concerns about the safety of the nuclear testing program have arisen, namely:[3]

1. *Does the fracturing of rock at Rainier Mesa pose a danger?*

The unexpected formation of a surface collapse crater during the 1984 Midas Myth test focused concern about the safety of testing in Rainier Mesa. The concern was heightened by the observation of ground cracks at the top of the Mesa and by seismic measurements indicating a loss of rock strength out to distances greater than the depth of burial of the nuclear device. The specific issue is whether the repeated testing in Rainier Mesa had fractured large volumes of rock creating a "tired mountain' that no longer had the strength to successfully contain future underground tests. The inference that testing in Rainier Mesa poses a high level of risk implies that conditions for conducting a test on Rainier are more dangerous than conditions for conducting a test on Yucca Flat.[4] But, in fact, tests in Rainier Mesa are buried deeper and spaced further apart than comparable tests on Yucca Flat.[5] Furthermore, drill samples show no evidence of any permanent decrease in rock strength at distances greater than two cavity radii from the perimeter of the cavity formed by the explosion. The large distance of decreased rock strength seen in the seismic measurements is almost certainly due to the momentary opening of pre-existing cracks during passage of the shock wave. Most fractures on the top of the mesa are due to surface span and do not extend down to the region of the test. Furthermore, only minimal rock strength is required for containment. **Therefore, none of the conditions of testing in Rainier Mesa—burial depth, separation distance, or material strength—imply that leakage to the surface is more likely for a tunnel test on Rainier Mesa than for a vertical drill hole test on Yucca Flat.**

2. *Could an accidental release of radioactive material go undetected?*

A comprehensive system for detecting radioactive material is formed by the combination of:

- the monitoring system deployed for each test;
- the onsite monitoring system run by the Department of Energy (DOE) and;
- the offsite monitoring system, run by Environmental Protection Agency (EPA), including the community monitoring stations.

There is essentially no possibility that a significant release of radioactive material

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[3] Detailed analysis of these concerns is included in chs. 3 and 4.

[4] Approximately 90 percent of all nuclear test explosions are vertical drill hole tests conducted on Yucca Flat. See ch. 2 for an explanation of the various types of tests,

[5] The greater depth of burial is due to convenience. It is easier to mine tunnels lower in the Mesa.

from an underground test could go undetected.

3. *Are we running out of room to test at the Test Site?*

Efforts to conserve space for testing in Rainier Mesa have created the impression that there is a' 'real estate problem" at the test site.[6] The concern is that a shortage of space would result in unsafe testing practices. Although it is true that space is now used economically to preserve the most convenient locations, other less convenient locations are available within the test site. **Suitable areas within the test site offer enough space to continue testing at present rates for several more decades.**

4. *Do any unannounced tests release radioactive material?*

A test will be preannounced in the afternoon 2 days before the test if it is determined that the maximum possible yield of the explosion is such that it could result in perceptible ground motion in Las Vegas. An announcement will be made after a test if there is a prompt release of radioactive material, or if any late-time release results in radioactivity being detected off the test site. The Environmental Protection Agency is dependent on the Department of Energy for notification of any late-time releases within the boundaries of the test site. However, if EPA is not notified, the release will still be detected by EPA's monitoring system once radioactive material reaches outside the test site. **If it is judged that a late-time release of radioactive material will not be detected outside the boundaries of the test site, the test may (and often does) remain unannounced.**

OVERALL EVALUATION

Every nuclear test is designed to be contained and is reviewed for containment.[7] In each step of the test procedure there is built-in redundancy and conservatism. Every attempt is made to keep the chance of containment failure as remote as possible. This conservatism and redundancy is essential, however; because no matter how perfect the process may be, it operates in an imperfect setting. For each test, the containment analysis is based on samples, estimates, and models that can only simplify and (at best) approximate the real complexities of the Earth. As a result, predictions about containment depend largely on judgments developed from past experience. Most of what is known to cause problems--carbonate material, water, faults, scarps, clays, etc.—was learned through experience. To withstand the consequences of a possible surprise, redundancy and conservatism is a requirement not an extravagance. Consequently, all efforts undertaken to ensure a safe testing program are necessary, and must continue to be vigorously pursued.

The question of whether the testing program is ''safe enough' will ultimately remain a value judgment that weighs the importance of testing against the risk to health and environment. In this sense, concern about safety will continue, largely fueled by concern about the nuclear testing program itself. However, given the continuance of testing and the acceptance of the associated environmental damage, the question of 'adequate safety' becomes replaced with the less subjective question of whether any improvements can be made to reduce the chances of an accidental release. In this regard, no areas for improvement have been identified. This is not to say that future improvements will not be made as experience increases, but only that essentially all suggestions that increase the safety margin have been implemented. **The safeguards built into each test make the chances of an accidental release of radioactive material as remote as possible.**

[6] See for example: William J. Broad, "Bomb l&Is: Technology Advances Against Backdrop of Wide Debate," New *York Times*, Apr. 15, 1986, pp. C1-C3.

[7] See ch. 3 for a detailed accounting of the review process.

The acceptability of the remaining risk will depend on public confidence in the nuclear testing program. This confidence currently suffers from a lack of confidence in the Department of Energy emanating from problems at nuclear weapons production facilities and from radiation hazards associated with the past atmospheric testing program. In the case of the present underground nuclear testing program, this mistrust is exacerbated by DOE's reluctance to disclose information concerning the testing program, and by the knowledge that not all tests releasing radioactive material to the atmosphere (whatever the amount or circumstances) are announced. As the secrecy associated with the testing program is largely ineffective in preventing the dissemination of information concerning the occurrence of tests, the justification for such secrecy is questionable.[8]

The benefits of public dissemination of information have been successfully demonstrated by the EPA in the area of radiation monitoring. Openly available community monitoring stations allow residents near the test site to independently verify information released by the government, thereby providing reassurance to the community at large. **In a similar manner, public concern over the testing program could be greatly mitigated if a policy were adopted whereby all tests are announced, or at least all tests that release radioactive material to the atmosphere (whatever the conditions) are announced.**

[8]See for example: Riley R. Geary, "Nevada Test Site's dirty little secrets," *Bulletin of the Atomic Scientists,* April 1989, pp. 35-38,