

Commentary

Transparency for nuclear weapons test sites

David Kramer reported in the February 2020 of *PHYSICS TODAY* (page 23) on the planned billion-dollar-plus upgrade to the diagnostics of US subcritical plutonium implosion experiments beneath the Nevada National Security Site. His excellent piece came eight months after the Defense Intelligence Agency (DIA) declared that “the U.S. government, including the Intelligence Community, has assessed that Russia has conducted nuclear weapons tests that have created nuclear yield.”¹ The Trump administration has not said when the alleged tests took place, only that they occurred after Russia signed the Comprehensive Nuclear-Test-Ban Treaty (CTBT)² in 1996.

The DIA declaration may have been a first step toward President Trump unsigning the CTBT as a group of Senate hawks urges, so that the US can resume nuclear explosive testing.³ For the president to unsign a treaty, however, would require that the Senate return it to him. The CTBT has been with the Senate since President Bill Clinton submitted it for ratification in 1997. Even though the US has not ratified the CTBT, the United Nations Vienna Convention on the Law of Treaties provides that a signatory to a treaty “is obliged to refrain from acts which would defeat the object and purpose of a treaty.” The departure of John Bolton and Tim Morrison from the National Security Council a few months after the DIA statement may, however, have taken the pressure off the CTBT for the moment.

The Trump administration’s public accusation that Russia is violating the CTBT probably relates to the suspicion that Russian weapons scientists have conducted hydronuclear experiments. In those experiments, plutonium is imploded into a barely supercritical mass that is then irradiated with a burst of neutrons at its point of maximum compression. The supercriticality results in



RN15 IN RESOLUTE, NUNAVUT, CANADA, is one of 80 radionuclide stations worldwide that watch for violations of the Comprehensive Nuclear-Test-Ban Treaty. (Photo from the CTBTO.)

a slow-growing fission chain reaction until the plutonium expands enough to become subcritical again. The fission-energy yield is typically less than the equivalent of a kilogram of chemical explosives.

The planned US subcritical experiments would have a fission-energy yield too, but a much smaller one. The proposed experiments would reach a maximum multiplication factor of about 0.95 from one generation of fissions to the next, with irradiation by a burst of neutrons to ignite a chain reaction. The neutrons could come from an external source or be produced in the plutonium by a beam of high-energy x rays causing photofissions. For target values of 10^{10} total fissions per experiment the fission energy yield would be about 0.3 joules, about the equivalent of that from the detonation of 0.07 milligrams

of chemical explosive.⁴ The fissions would, however, release enough prompt gamma rays so that the die-away of the fission chain reactions over a hundred nanoseconds or so could be used to measure the level of criticality achieved and thereby the compressibility of the plutonium.

Article I of the CTBT defines banned activity only as “any nuclear weapon test explosion or any other nuclear explosion.” It is therefore necessary to review the statements of the negotiators to shed light on where to draw the line. In 2011 the US State Department put out a collection of statements made by the officials of the five nuclear-armed states that are parties to the Nuclear Non-Proliferation Treaty; France, Russia, and the UK, unlike the US and China, have ratified the CTBT.⁵ Here are three of the most relevant statements.

- The CTBT “permits experiments . . . including those of the explosive nature, but under the condition that they are purely chemical (the so-called ‘hydrodynamic experiments’).” —Grigory Berdennikov, chief Russian negotiator, 7 December 2005.
- “My government’s position [is] that the CTBT should not permit any nuclear weapon test explosion involving any release of nuclear energy, no matter how small.” —John Weston, UK ambassador to the United Nations, 14 September 1995.
- “It maintains the possibility of testing called ‘cold’ tests and ‘subcritical’, no nuclear chain reaction.” —Serge Vinçon, former vice president of the French Senate, 25 March 1998.

When the CTBT was submitted to Congress in 1997, the State Department included an article-by-article analysis with the following statement:

The U.S. decided at the outset of negotiations that it was unnecessary, and probably would be problematic, to seek to include a definition in the Treaty text of a “nuclear weapon test explosion or any other nuclear explosion.” . . . It is clearly understood by all negotiating parties, as a result of President Clinton’s announcement on August 11, 1995, that the U.S. will continue to conduct a range of nuclear weapon-related activities to ensure the safety and reliability of its nuclear weapons stockpile, some of which . . . may result in the release of nuclear energy. Such activities . . . could include: . . . inertial confinement fusion . . . and hydrodynamic experiments, including subcritical experiments involving fissile material. None of these activities will constitute a nuclear explosion.

I don’t believe that neutron-irradiated subcritical experiments were discussed in the negotiations. Since they involve nuclear chain reactions and are not purely chemical, they fall between cold, allowed subcritical tests and the forbidden, barely supercritical hydronuclear tests. They allow the US to accomplish, with its billion-dollar-plus setup, what Russia or China could accomplish much more cheaply with hydro-nuclear tests.

Recently, after the DIA accused Russia of cheating, the State Department offered the following explanation:

Dating back to 1993, the United States has defined its own nuclear testing moratorium as a commitment not to conduct “nuclear explosive tests”, and after August 1995 made clear that this means any test that produces a self-sustaining, supercritical chain reaction of any kind. This is what the United States refers to as the “zero-yield” standard. Beginning with President Clinton’s announcement in August 1995, the United States led efforts to ensure the Comprehensive Test Ban Treaty (CTBT) was a “zero-yield” treaty, but these efforts did not produce a documented agreement among the nuclear weapons states on a definition of “nuclear explosion.”⁶

Although the CTBT established the now-operational global nuclear-test-monitoring network, the treaty-mandated option for short-notice, on-site inspections of test sites is not yet available because the treaty has not formally entered into force.

To help clarify whether their ongoing experimental activities are fully compliant with the zero-yield ban on testing, nuclear-weapons-state signatories to the CTBT could pursue test-site transparency procedures. One approach would allow measurements of induced radioactivity or neutron transmutation products in the containment vessels to determine the fission yield after subcritical tests.

Unfortunately, Russia refuses access to its Novaya Zemlya test site until the US ratifies the CTBT, as Russia has. In the case of China, Los Alamos physicists visited the Chinese Lop Nor test site 10 times⁷ between 1990 and 2001. The visits were to be reciprocated, but when the Chinese delegation arrived in the US, their permission to visit the US test site was vetoed in the Department of Energy, and they were given briefings at Livermore instead. Since then, the Chinese have not been interested in transparency unless the US goes first. As Kramer’s report illustrates, the US weapons labs have been open in publishing photos and descriptions of their subcritical-experiment setups. How-

ever, the Trump administration is not encouraging them to discuss test-site transparency.

All 184 signatories to the CTBT would do well to support additional test-site transparency measures to reinforce the quarter-century moratorium on nuclear testing by the nuclear-weapons-state signatories.

References

1. Defense Intelligence Agency, “DIA statement on Lt. Gen. Ashley’s remarks at Hudson Institute” (13 June 2019).
2. US State Department, *Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments* (August 2019), p. 40.
3. P. Sonne, “U.S. military intelligence steps up accusation against Russia over nuclear testing,” *Washington Post*, 13 June 2019.
4. D. J. Funk, “Enhanced Capabilities for Subcritical Experiments (ECSE): Portfolio Overview,” rep. no. LA-UR-18-28253, Los Alamos National Laboratory, PowerPoint presentation (2019), slide 48.
5. US Department of State, “Key P-5 Public Statements on CTBT Scope,” 26 January 2011.
6. Ref. 2, p. 39.
7. T. C. Reed, D. B. Stillman, *The Nuclear Express: A Political History of the Bomb and Its Proliferation*, Zenith Press (2009), chap. 14 and app. E.

Frank N. von Hippel
(fvhippel@princeton.edu)
Princeton University
Princeton, New Jersey

LETTERS

A nod to Philip Bevington

I read with appreciation Charles Day’s important, lucid, and interesting editorial on reproducibility (PHYSICS TODAY, December 2019, page 8). When he mentioned the need for better education in data analysis and named Philip Bevington’s *Data Reduction and Error Analysis for the Physical Sciences* and its importance to him, I gasped audibly. For the first time, I appreciated how much that one small, clear tome had influenced not only my career but my whole approach to life and decision making in nontechnical areas.

For me, Bevington, as the book was affectionately known in my undergrad