The CTBT and Zero Yield: A Technical Perspective

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Zero Yield and
The Comprehensive Test Ban Treaty

• Basic obligation of the CTBT:
  – Party states will not carry out a nuclear explosion

• The treaty is often referred to as a “zero yield” treaty
  – “Zero”, “yield”, and “threshold” do not appear in the treaty text
  – A “true zero yield comprehensive test ban” was the United States goal

• A yield threshold that defines a nuclear explosion is not established by the treaty
  – As opposed to the 150 kt limit in the 1974 Threshold Test Ban Treaty
What is Yield?

• **Yield is energy (SI unit is the Joule)**
  – Nuclear weapon explosive output is often measured in kilotons of TNT equivalent
    • $1 \text{ kt} = 4.8 \times 10^{12} \text{ J}$
  – You probably pay your electric bill in kWhrs
    • $1 \text{ kWhr} = 3.6 \times 10^6 \text{ J}$
  – Do you count calories?
    • $1 \text{ g of sugar} \approx 4 \text{ g of TNT}$

• **Energy is the integral of power over time (Watts)**

When does the release of nuclear energy become an explosion?
Nuclear Yield from Natural Events

- Energy release at the nuclear level is typically described in units of MeV
  - 1 MeV = 1.602x10^{-13} J
- Many nuclides relevant to nuclear weapons decay by alpha emission, and to a lesser extent, spontaneous fission
  - Explosive at the atomic level
- Consider a significant quantity of plutonium (8 kg)
  - Alpha decay results in ~17 W of power
  - In 5 minutes, more than 1 g TNT equivalent is released
    - Fission yield of 1 g would take a couple years
Stimulated Nuclear Yield

- **Fissile materials can be carefully arranged to multiply neutrons**
  - Nuclear reactors manipulate neutron population to produce power at a constant rate
  - Test reactors can be pulsed
  - Nuclear explosions can be initiated

- **Weapons States reserved the right to conduct hydrodynamic nuclear experiments that remained subcritical under the CTBT**
  - Explosively driven assembly of nuclear materials that results in increased neutron multiplication rates
  - Nuclear yield is stimulated past levels that would naturally occur with that quantity of material in the time span of the experiment

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*Low yield to high yield configurations of nuclear material*
Why Not a Threshold?

• The idea of “zero yield” is important because a threshold sanctions nuclear testing at some level
  – Potential thresholds were discussed during CTBT negotiations, should one become necessary
    • United States favored a limit of a few pounds
    • France and Russia favored higher limits
    • China argued for several hundred tons

• An established threshold may cede a perceived technical advantage
Achieving Zero Yield?

• “Zero yield” is not a technically viable statement
  – Not an achievable state in nature
  – Impractical measure of CTBT compliance

• “Hydro-nuclear” yields greater than zero are at least tacitly accepted under the CTBT
  – Miniscule yield is still greater than zero

• A threshold exists in practice

“When I use a word, it means just what I choose it to mean -- neither more nor less”
Humpty Dumpty in Lewis Carroll's Through the Looking Glass