United States Department of the Interior

BUREAU OF MINES

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May 25, 1982-01

Dr. Lawrence Chase
Nuclear Regulatory Commission
Washington, D.C.

Dear Dr. Chase:

In response to the question you posed in our discussion on Friday May 21, 1982 - Can weapons tests be conducted in the proximity of an underground waste repository on the NTS?

It is impossible to state an absolute yes or no, since there is an insufficient amount of data available from which an evaluation can be made. However some parameters and conditions can be assumed from which some reasonable limitations can be developed as a starting point.

First, the maximum level of ground motion (level of vibration) must be established that will preclude damage to the repository and its surface and access facilities. The damage threshold for surface structures that has been widely accepted is 2.0 in/sec. peak particle velocioty. However, recent research indicates a lower limit of 1.0 in/sec for frequencies below 40 Hz should be considered.

Bureau of Mines, DRC research on the proximity of surface blasting to underground coal mines, indicates no effect on the integrity of the mine opening support systems or adverse effect on the mine openings for peak particle velocities up to 2.0 in/sec. Although 40% of the data exceeded 2.0 in/sec up to a maximum of 17 in/sec, the only effect was the dislodging of loose pieces from the roofs and ribs and was not considered to be damage.

However, because of the limited data base and the lack of a definitive definition of what constitutes damage, a maximum limit of 2.0 in/sec has been proposed at this time. Also, this is an acceptable limit for most surface structures.

Since our results are from relatively small charge weights (maximum of 12,500 pounds), significantly different geologic and physical environments and the detonations were designed to break and move rock rather than transfer energy into the host medium - the resultant regression equations are not applicable to the conditions at the NTS.

The following equations (1) can be used for the NTS since they are based on actual measurements. However they do not necessarily apply to an underground opening since they are generally surface measurements.



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There are two equations for determining the expected peak particle velocity

$\nu = 3.36W^{.77} R^{-1.51}$ hard rock

$\nu = 5.10W^{.635} R^{-1.31}$ alluvium

where $\nu$ is in cm/sec

W is in kt

R is in km

Using these equations and the following confining parameters of:

$\nu$ = 2.0 in/sec (5.08 cm/sec)
W = 40 kt
R = 1 mile (1.609 km)

At a 1 mile distance, the maximum charge weights for 2.0 in/sec are:

W = 4.35 kt hard rock

W = 2.65 kt alluvium

At a charge weight of 40kt, the distances required to maintain 2.0 in/sec are:

R = 3.1 miles (4.99 km) hard rock

R = 3.72 miles (5.99 km) alluvium

Another effect that must be considered is the charge size versus the frequencies generated and propagated to the repository. To predict this, is at best, somewhat circumspect due to variation in actual yield and the absorption/dispersion in the media.

Using an equation (2) developed from past Bureau of Mines research, it is possible to obtain a general prediction range of frequencies. Although the equation is for salt, which is highly transmissive, it has been used to successfully predict the expected frequency range from an undergrund nuclear detonation.(3)

$f = 1.7 \cdot 10^3 W^{-0.32}$ W is in pounds

for W = 40kt f = 4.03 Hz

for W = 4.35 kt f = 10.23 Hz

Recognizing the high probability of inaccuracy at these specific frequencies, one can establish a range of ±50%.

for W = 40 kt f = 2.515 to 10.06 Hz

for W = 4.35 kt f = 5.115 to 20.46 Hz

At this point one can establish some information regarding the wavelengths of the signal frequency relative to the dimensions of the underground repository. If the wave length is shorter than the opening it will act as a free surface and a double amplitude can be expected. Further, the opening will not react as a unit which could cause damage.

To determine the wavelengths of the minimum/maximum expected frequencies, the propagation velocity must be known. A nominal value of 15,000 ft/sec is assumed. Using the equation $\lambda = V/f$ results in the following:

40kt $\lambda$ = 5964 to 1491 feet

4.35kt $\lambda$ = 2933 to 733 feet

Other factors that can have a significant effect are: the overburden loading pressure, the regional stress, the horizontal compressive stress ratio, topographic features, propagation path, orientation of the repository relative to the source and the actual yield of the device.

The equation for recording stations located on alluvium was included to demonstrate the amplification effect. I hope this information is useful toward answering the basic question.

I look forward to future participation in this program.

Sincerely,

Robert D. Munson
Geophysicist


(1) Analysis of Seismic Peak Amplitudes from Underground Nuclear Explosions, L.H. Murphy & J.A. Lahound NVO-1163 - 166, 1968 Table 3.

(2) Dynamic Rock Mechanics Investigations, Project Cowboy APRL 38-3.2, 1960, H.R. Nicholls, V.E. Hooker & W.I. Duvall.

(3) Vibration Response & Evaluation of Oil Shale Mine Openings to the Rio Blanco Event. R.D.: Munson. Contrat AT (29-) 914 USBM 10013, 1975.