WEAPONS EFFECTS 3

3.1 DESCRIPTION OF EXPLOSION FORCES

An explosion is an extremely rapid release of energy in the form of light, heat, sound, and a shock wave. The shock wave consists of highly compressed air that wave-reflects off the ground surface to produce a hemispherical propagation of the wave that travels outward from the source at supersonic velocities (see Figure 2-1). As the shock wave expands, the incident or over-pressures decrease. When it encounters a surface that is in line-of-sight of the explosion, the wave is reflected, resulting in a tremendous amplification of pressure. Unlike acoustical waves, which reflect with an amplification factor of two, shock waves can reflect with an amplification factor of up to thirteen, due to the supersonic velocity of the shock wave at impact. The magnitude of the reflection factor is a function of the proximity of the explosion and the angle of incidence of the shock wave on the surface.

The pressures decay rapidly with time (i.e., exponentially), measured typically in thousandths of a second (milliseconds). Diffraction effects, caused by building features such as re-entrant corners and overhangs of the building may act to confine the air blast, prolonging its duration. Late in the explosive event, the shock wave becomes negative, followed by a partial vacuum, which creates suction behind the shock wave(see Figure 3-1). Immediately following the vacuum, air rushes in, creating a powerful wind or drag pressure on all surfaces of the building. This wind picks up and carries flying debris in the vicinity of the detonation. In an external explosion, a portion of the energy is also imparted to the ground, creating a crater and generating a ground shock wave analogous to a high-intensity, short-duration earthquake.

The peak pressure is a function of the weapon size or yield, and the cube of the distance (see Figure 3-2). For an explosive threat defined by its charge weight and standoff, the peak incident and reflected pressures of the shock wave and other useful parameters such as the incident and reflected impulse, shock velocity, and time of arrival are evaluated using charts available in military handbooks.

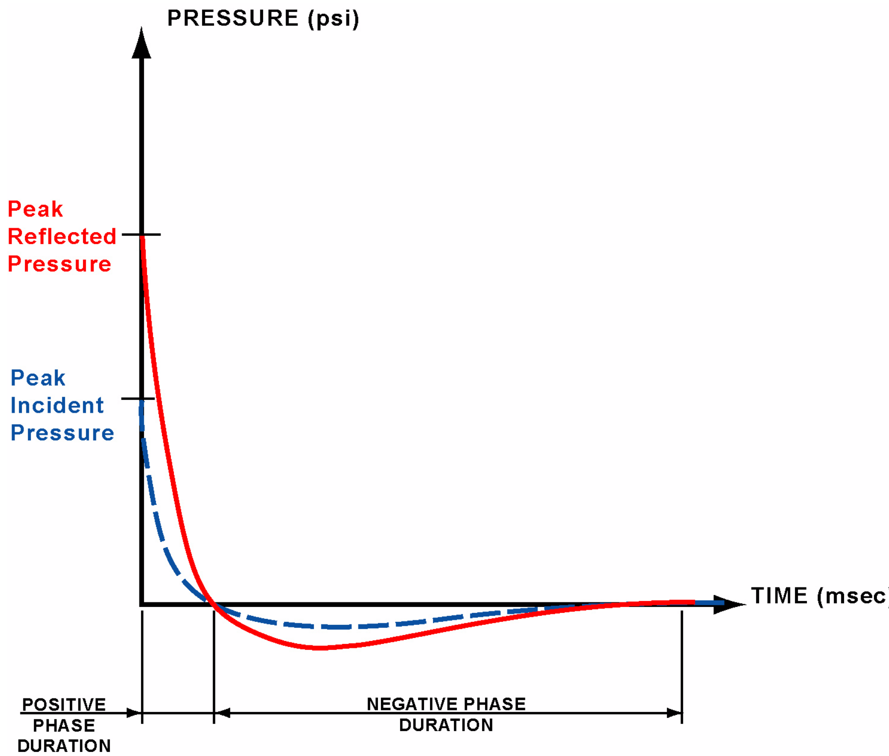

Figure 3-1 Air-blast pressure time history

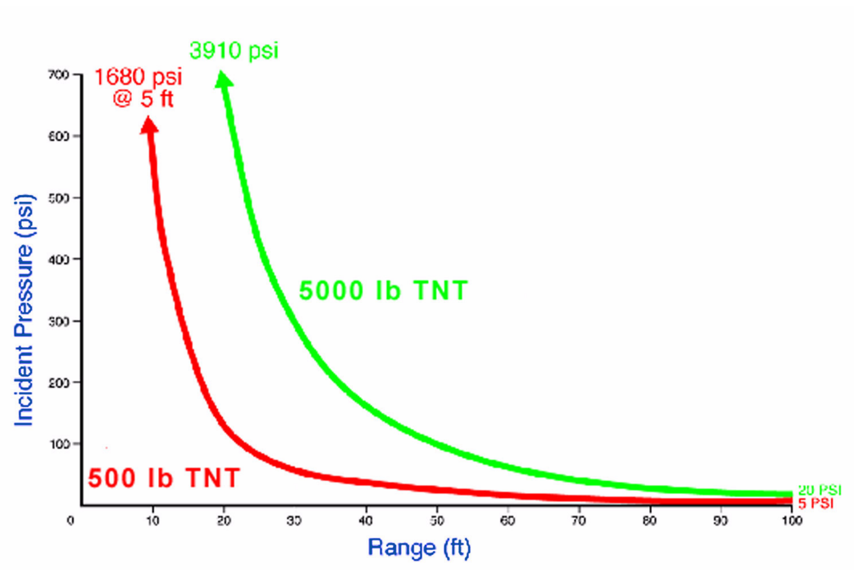

Figure 3-2 Plots showing pressure decay with distance

3.2 FURTHER READING

These references provide charts for evaluating explosive loads as well as extensive information regarding the structural design of buildings to resist explosive attack.

U.S. Air Force, 1989, *ESL-TR-87-57, Protective Construction Design Manual,* Contact Airbus Technologies Division (AFRL/MLQ) at Tyndall Air Force Base, Florida, via e-mail to techinfo@afrl.af.mil. [Superseded by Army Technical Manual TM 5-855-1 (Air Force Pamphlet AFPAM 32-1147(I), Navy Manual NAVFAC P-1080, DSWA Manual DAH-SCWEMAN-97), December 1997]

U.S. Army Corps of Engineers, 1990, TM 5-1300, *Structures to Resist Accidental Explosions,* U.S. Army Corps of Engineers, Washington, D.C., (also Navy NAVFAC (Naval Facilities) P-397, Air Force Regulation 88-2); Contact David Hyde, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180 or via e-mail to hyded@ex1.wes.army.mil

U.S. Department of Energy, 1992, DOE/TIC 11268, *A Manual for the Prediction of Blast and Fragment Loadings on Structures,* Southwest Research Institute, Albuquerque, New Mexico.