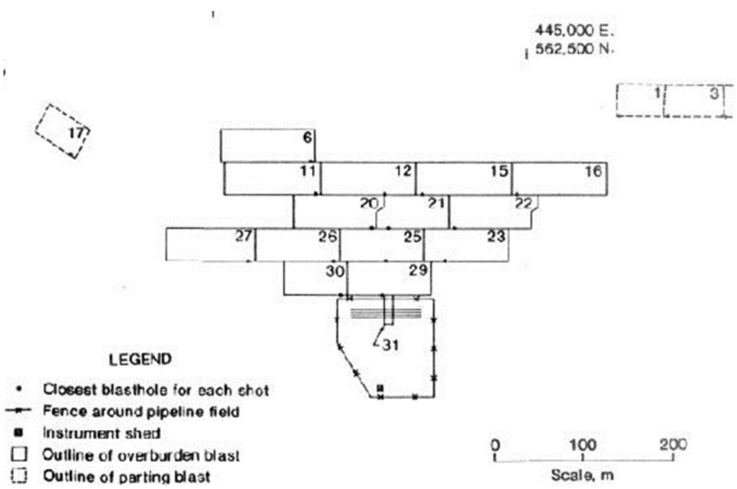
CONST-VIBRATION listserv Newsletter #20
Full Scale Field Testing of Buried Pipe Integrity Demonstrates that a
Variety of Steel Pipe Sizes Can Withstand Peak Particle Velocities Well Above 125 mm/s



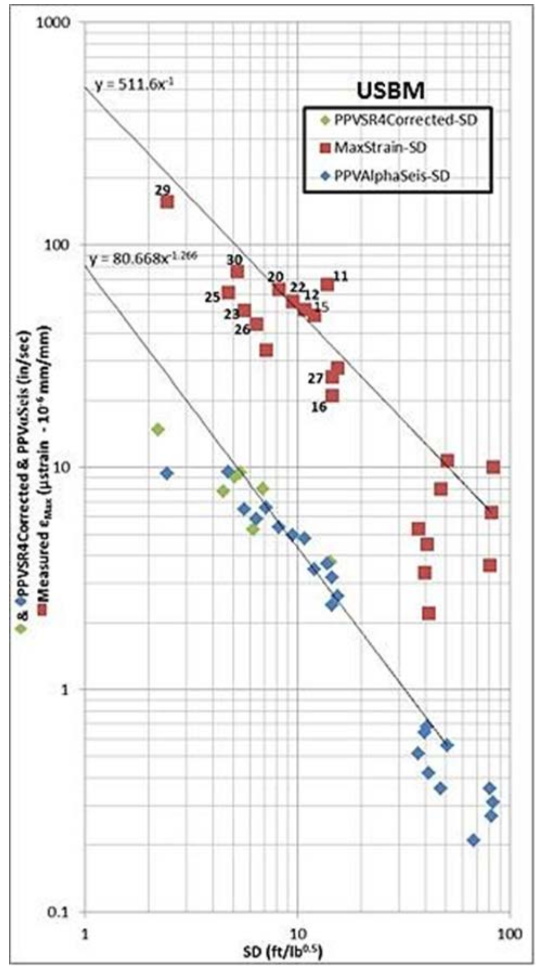


Figure 1 (top left): Result of last shot 31 directly beneath the pipes, which had to be literally blown out of the ground to damage them (Figure 33; USBM RI 9523, 1994)
Figure 2 (bottom left): plan view of test shot locations relative to the buried pipes (left to right lines shown across "31", the location of the last shot. (Figure 1; USBM RI 9523, 1994)
Figure 3 (right): RI 9523 peak particle velocities and peak (longitudinal or hoop) strains vs scaled distance. PPV -- in/sec x 100 and stain -- mm/mm x 10-6 or micro strain (Dowding & Akayya, 2013)

Large, full-scale blast tests conducted by the U. S. Bureau of Mines (USBM) showed that pressurized welded steel pipelines can withstand particle velocities greater than 23 ips without damage (Siskind, et al., 1995). The test program, conducted at an AMAX Coal Company mine in Indiana involved large, multiple-delay blasts adjacent to four buried welded steel pipelines (16.8 to 50.8 cm in diameter) and one PVC pipe (21.9 cm in diameter) shown in Figure 2. The geologic cross section or profile, including the pipeline field area, consisted of about 2 m (6 ft) of clayey soil overlying about 12 m (40 ft) of shale, which in turn overlay two coal seams and a parting. Although the pipelines were trenched in the soil overburden, the propagation path for the vibration waves is principally through the shale rock.

Fragmentation and ground motions were produced with 31 and 27 cm (12.25 and 10.63 in) diameter blast holes. Charge weights per delay varied between 380 and 300 kg (830 and 670 lbs). Shots 25 and 29 were detonated within 4.6 and 15 m (15 and 50 ft) respectively of the test pipelines. Resulting blast-induced strains in the 50.8 cm diameter pipe reached 156 μ inch per inch and surface ground motion above the 50.8 cm diameter pipeline exceeded 600 mm/s.

Pipes were pressurized to model operating conditions, so internal pipeline pressure was monitored to determine if ground motions led to loss of pressure. Steel pipelines were pressurized at 6.2 Mpa (900 psi) and PVC at 0.62 MPa (90 psi). All of pipeline pressures were periodically checked for leakage. No loss of pressure was detected in any of the steel pipes until they were deliberately blown out of the ground as shown in Figure 1 with the last shot, 31, to produce damage.

While the USBM test program provides valuable data on pipeline performance in blasting situations, the recommended control limit, 125 mm/s (5ips), seems low due to the conservatism, particularly for modern, welded steel pipelines in good condition. This limit is based on a number of conservative factors and assumptions, the most notable of which involves the use of a linear relationship (Fig. 35 in RI 9523) of pipeline hoop (circumferential) strain versus peak particle velocity that envelopes all of the measured data. The resulting linear relationship is controlled by a single data point at a peak particle velocity of approximately 2 ips, with a majority of test points falling well below the relationship.

Scaled distances employed for comparing field measurements can be confusing and possibly misleading when comparing radically different shot types. While the scaled distances can be roughly the same for the trench and surface mining shots, absolute distances will differ significantly. For instance at a scaled distance of 10 ft/lb$^{1/2}$, the absolute distance for a trench shot would be 30 ft for a shot with a charge per delay of 10 lbs. At the same scaled distance the stand-off distance for a surface mining shot would be 300 ft for a charge per delay of 850 lbs. Newsletter #22 will compare strains from trenching shots with USBM surface coal mining blasts.

References

Dowding, C.H. and Akayya, U. (2013) "Importance of Ground Strain in Predicting Blast-induced Strain and Stress in Pipelines" Proceedings: RocDyn1 EFPL Lausanne, SW. Available at http://www.civil.northwestern.edu/people/dowding/acm/.

Siskind, D.E., Stagg, M.E, Wiegand, J.E., and Schulz, D.L. (1994) USBM Report of Investigations 9523, Surface Mine Blasting Near Pressurized Transmission Pipelines. Available through ARblast; https://www.osmre.gov/resources/blasting/arblast.shtm.