Preliminary Large-scale DDT Experiments at NIOSH Lake Lynn Laboratory

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Preliminary methane-air deflagration-to detonation transition (DDT) experiments are performed to examine whether DDT could occur in sealed areas of underground coal mines. The detonation tube used for these studies is 73 m long, with the internal diameter d=105 cm, and closed at one end. The test gas is 97.5% methane with about 1.5% ethane, and the composition of methane-air mixtures varied between about 7 to 14% methane by volume. Flame evolution was observed for a spark ignition in the tube with a limited number of baffles (orifice plates) near the closed end. In all experiments, baffles with a blockage ratio BR = 0.6 and spaced at S = d were added to the detonation tube starting from the closed end. The number of baffles was systematically increased from 0 to 20. In a test without baffles, the flame in near stoichiometric mixture accelerated very slowly and only reached a velocity of less than 100 m/s upon exiting the tube. Maximum pressure was less than about 0.5 MPa. For tests with 6 or more baffles, the flame in near stoichiometric mixture accelerated rapidly to over 600 m/s and generated strong shocks with a magnitude of 1.5 MPa or more. DDT appeared in the smooth section of the tube far outside the last baffle in tests with 9, 10, 11, and 18 baffle sets. For tests where detonations appeared, the flame speed before DDT had reached a velocity of 750 m/s or more, and the shock speed had reached a velocity of 800 m/s or more. So far, the tests were performed for up to 20 baffles, and DDT has not been observed within the obstructed section of the tube. The mechanism for the DDT in the smooth section of the tube is not well understood, but data analysis shows that DDT is related to fast flames and possibly detonations that bypass the main detonation tube through the gas mixing and recirculation system. More studies are needed to understand this mechanism of DDT using experiments that prevent the flame bypass via the recirculation system. Additional experiments are underway with more baffles and with different BR. Experiments also show that it is possible to develop high flame speeds and high shock pressures for mixture compositions that are far from stoichiometic.

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Figure 1 - Overview of the gas explosion test facility (GETF) for large-scale, methane-air detonation and DDT experiments at NIOSH Lake Lynn Laboratory.

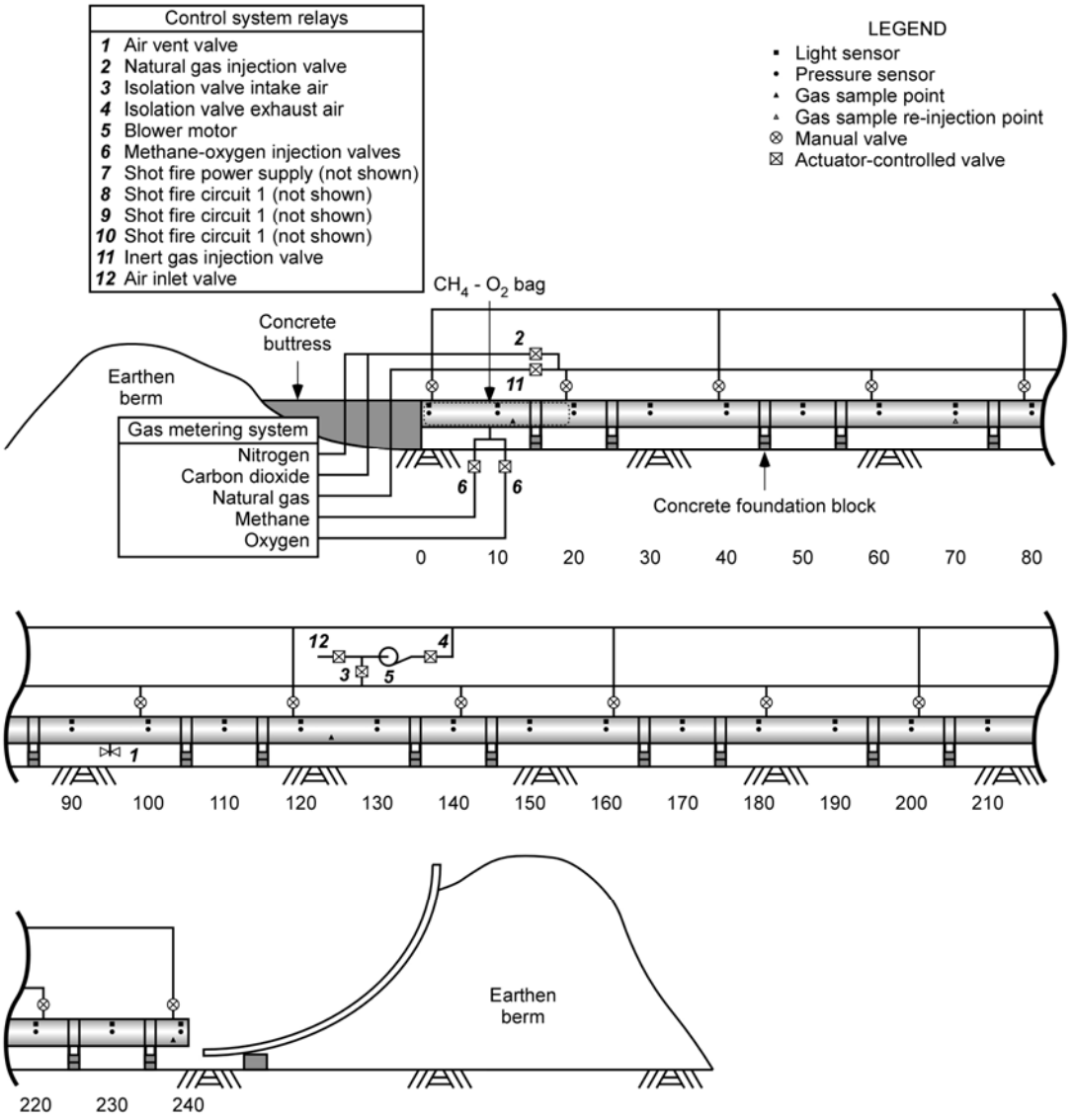

Figure 2 - Schematic of the GETF at NIOSH Lake Lynn Laboratory showing all major components including the gas mixing and recirculation system.

Figure 3 – Baffles with blockage ratio BR = 0.6 and spacing S=d=105 cm installed in the tube.

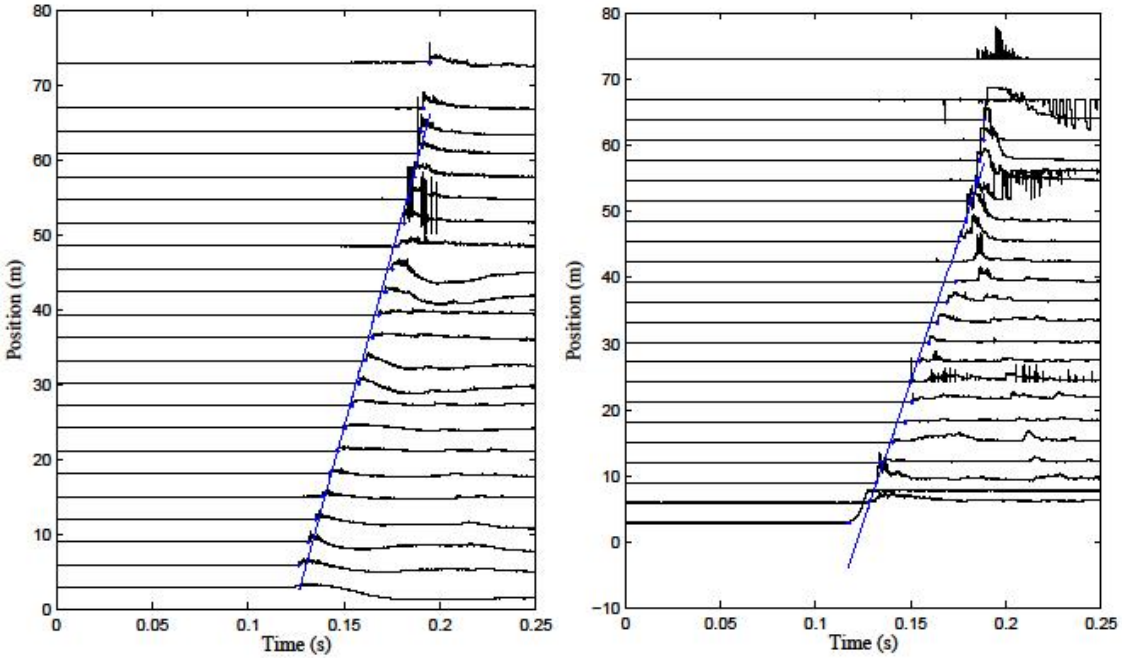

Figure 4 - Shock (left) and flame (right) position versus time data for test # 68 using 10.45% methane-in-air. DDT appears at about 50 meters where the flame and shock speed continue at about 1800 m/s. Note the retonation wave originating at 50 m that propagates back toward the closed end of the tube.