LARGE-SCALE VENTED DEFLAGRATION TESTS

Peter A. Diakow, J. Kelly Thomas and Philip J. Parsons
Baker Engineering and Risk Consultants, Inc.
3330 Oakwell Court, Suite 100
San Antonio, TX 78218-3024
(210) 824-5960
pdiakow@BakerRisk.com

This paper presents results from a test program carried out to determine the peak deflagration pressure achieved within a congested enclosure vented through one wall of the enclosure. The industry standard in the United States for predicting the peak pressure developed in a vented deflagration is the National Fire Protection Association’s Standard on Explosion Protection by Deflagration Venting (NFPA 68). The NFPA 68 (2013 edition) vent area correlation accounts for the effect of congestion if the ratio of the obstacle surface area ($A_{obs}$) to that of the enclosure ($A_s$) is greater than 0.4 (i.e., $A_{obs}/A_s > 0.4$). The tests described in this paper were performed using an obstacle array with an $A_{obs}/A_s$ ratio of less than 0.4.

These tests were conducted in a rig with a 48-foot width, 24-foot depth, and 12-foot height. The rig was enclosed with solid walls, roof and floor, allowing for venting through one of the long walls (i.e., 48-foot by 12-foot). The venting face of the rig was sealed with a 6 mil (0.15 mm) thick plastic vapor barrier to allow for the formation of a near-stoichiometric propane-air mixture inside the rig. The flammable gas cloud was ignited near the center of the rear wall. Steel vent panels (20 gauge) were installed over the plastic vapor barrier using explosion relief fasteners. The vent panels weighed 2 lb/ft$^2$ and were configured to release at 0.3 psig; vent panel restraint devices were not utilized. The congestion inside the rig was provided by a regular array of vertical cylinders (2-inch schedule 40 pipe and 2-inch outer diameter cylinders) giving area and volume blockage ratios (ABR and VBR) of 4.9% and 2.2%, respectively, within the congestion array. The obstacle to enclosure surface area ratio ($A_{obs}/A_s$) for this obstacle array pattern is 0.3 if the array is extended throughout the rig, which is less than the critical value to account for congestion in the NFPA 68 correlation.

Four series of tests were conducted with varying vent parameters, flammable gas cloud sizes and congestion levels. The baseline tests were performed with the congestion array and flammable gas cloud extending throughout the rig and without vent panels present (i.e., vapor barrier only). The second test series included vent panels. The third test series utilized a flammable gas cloud which filled only the back half of the rig. The congestion array only covered $\frac{1}{4}$ of the rig in the fourth test series. The peak pressures and impulses for each test are provided in this paper, along
with pressure histories internal and external to the rig for selected tests. The steel vent panel throw distance is also provided as a function of internal peak pressure.

Comparisons are shown with the vent area correlations provided in the NFPA 68 standard. For all but the fourth test series (i.e., congestion array filling \( \frac{1}{4} \) of the rig), the average peak pressures achieved within the rig were approximately a factor of 2 larger than those predicted by NFPA 68.