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Case Study

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SHELTER IN PLACE DESIGN FOR TOXIC AND FLAMMABLE HAZARDS: CASE STUDY

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1 Introduction

This case study will present findings from a project where BakerRisk developed risk mitigation options to protect the occupants of a control room building from the consequences posed by toxic hazards in a Chemical Processing facility. The primary hazards considered in the study were Ammonia and, hydrogen sulfide. For the purpose of determining the maximum concentrations that would occur inside the building, infiltration rate for the building was determined using a CO_2 tracer gas test. Furthermore, infiltration rate for various weather conditions was predicted using analytical models.

1.1 Dispersion Analysis

First a dispersion analysis was performed to calculate the toxic concentration outside the building. Ammonia and hydrogen sulfide were considered in the study from the release sources. Maximum concentrations in the building were calculated based on infiltration rate determined using a CO_2 tracer gas test. Also, infiltration rate for various weather conditions was predicted using known weather conditions. In addition, effects of increasing wind speed and temperature differential on the infiltration rate was investigated. Although the rate of infiltration into the building is directly proportional to the wind speed, the maximum exterior concentration is inversely proportional to wind speed. Therefore, a sensitivity analysis was performed on various scenarios to determine if different wind speed ranges should be considered in this study. The design period for the control room was chosen as 60-minutes for which the governing

concentration thresholds for each toxin were determined. Thus, indoor toxic concentrations that exceeded the threshold values will warrant evacuation or mitigation procedures for personnel.

Toxin infiltration due to operation of the HVAC, exterior concentration and building's infiltration rate was calculated over time. Analysis showed that only hydrogen sulfide release exceeded the acceptable threshold at the building location. More specifically, toxic clouds of the hydrogen sulfide could reach the building in 5 minutes or less, the maximum exterior toxic concentration at the building is 600 parts per million (ppm), the maximum interior toxic concentration at 60 min of exposure is 140 ppm and most importantly, the interior hydrogen sulfide concentration can exceed the acceptable limits in less than 10 minutes. From a vulnerability standpoint, occupants will have 50 minutes before the concentration exceeds a dosage required to sustain a fatality rate of 0.1%.

Internal concentrations of flammable gases were also determined using the same approach. The interior flammable concentration values were compared to the lower flammability limit (LFL) to determine whether or not they had the potential to ignite. Based on analysis results, only two scenarios caused internal concentrations to increase above the LFL before the 60-minute mark and these cases took between 50-55 minutes to reach the LFL inside the building.

1.2 Recommendations

Based on these findings, BakerRisk developed three design recommendations for mitigation of toxic exposure. First option utilized a clean air supply to create a positive pressure environment within the building. The second option considered the use of a direct air supply (Air Bottles) for the operators in the control room to provide breathing air for the maximum expected duration of the emergency operation. The last option consisted of increasing the leak tightness of the building and using gas scrubbers to clean the toxics that would infiltrate in the building. The

presentation of the case study will include a discussion on the hazards, methodology and the proposed mitigation measures.