Executive Summary

Flares are commonly used during petroleum refining and chemical processing for safe disposal of waste gases during process upsets and/or plant startup/shutdown and process emergencies to combust the organic content of waste streams. This project was initiated to investigate flare mass flow rates/chemical species as a function of process plant type, feedstock, and operation mode in the Houston/Galveston Area (HGA); and to study possible intermediates/by-products by using computer simulation packages.

This project included an HGA (Chambers, Harris, Galveston, Brazoria, Fort Bend, and Montgomery counties) plant wide analysis of yearly reported data from TCEQ's (Texas Commission on Environmental Quality) on-line emission event reporting system from January 1, 2006 through December 31, 2006. In general, characteristics of HRVOC emissions depend on the type of the plant and on the process upset equipment. Emission spectrums for four counties (Brazoria, Galveston, Chambers, and Harris) were analyzed and presented in this report. The major contributing species for flaring in HGA are ethylene, propylene, ethane, propane, and 1-3 butadiene.

The effect of variability in critical flare operating factors such as air supply, steam injection, and flaring gas temperature on by-products formation was studied by using three computer simulation packages. Simulation with R-Gibbs Reactor (AspenPlus) was performed to study the effects of air flows and temperature at fixed steam injection using ethylene, propylene, and benzene as the feed. An emission rate of 0.003 to 0.011 kmole/hr of formaldehyde from flaring was predicted by R-Gibbs simulation modeling under severe air deficiency. Simulation with CHEMKIN suggested the possibility of the formation of intermediates, including acetylene and formaldehyde. The degree of conversion and the concentrations of intermediates depended on temperature and resident time within the flare. Currently, the simulation results indicate that about 10 ppb of formaldehyde is formed as the intermediate. Gaussian simulation also supported these findings. Further simulations with FLUENT, in conjunction with CHEMKIN, are necessary to simulate the incomplete combustion and unstable flame, as well as the temperature distribution in various flare zones to obtain more rigorous flaring results, especially with regard to the formation of aldehydes. The effects of high/low flare throughput (high/low exit velocity), cross wind (weather), under/over-steaming,

under/over-aeration on flare destruction efficiency, and incomplete combustion products are the recommended areas for future research.