

Executive Summary

Recent studies have indicated that industrial sources of emissions, in particular those associated with highly reactive volatile organic compounds (HRVOCs) defined as ethylene, propylene, 1,3-butadiene and butenes, exhibit high temporal emission variability that can significantly impact on ozone formation in the Houston-Galveston-Brazoria area. However, photochemical air quality models used to evaluate the effectiveness of ozone reduction strategies typically assume that the temporal profiles of industrial emissions are nearly constant. The primary objective of this project was to characterize the temporal emission profiles for flares from petroleum refineries, chemical manufacturing facilities, and other classes of industrial facilities. In addition, recommendations for control strategy evaluation for components of the continuous emissions from flares were developed.

In 2006, during the Second Texas Air Quality Study (TexAQS II), the Texas Commission on Environmental Quality (TCEQ) assembled reported emission data from 141 industrial site locations with more than 600 emission sources, including stacks, flares, cooling towers and fugitive sources. The data were collected for 32 days (August 15 through September 15, 2006) at one hour intervals. The database represents the largest collection of hourly industrial emissions for a single metropolitan area in the United States and is complemented by extensive ambient data collected within the same geographic region and time period. The emissions database was incorporated into a 2006 Special Inventory (SI) by the TCEQ.

This document reports on the use of this unique database to identify temporal patterns of industrial emissions sources. For quality assurance purposes, the 2006 SI emissions were first compared with historic data. In particular, the emissions were compared to a recently developed speciated 2005 ozone season day (OSD) point source emission inventory for the purpose of identifying major sources in the area, as well as any potential discrepancies. Comparison at the emission point level revealed significant differences in emissions for individual sources. However, when total volatile organic compound (VOC) emissions in the study area were compared, the 2006 SI emissions were within 12% of emissions from matched emission points in the 2005 OSD (i.e. 37 tpd in 2006 vs. 33 tpd in 2005 OSD) suggesting that, on average, the 2006 hourly data were in reasonable agreement with historic data.

Since the majority of the VOC and HRVOC emissions in the 2006 SI originated from flares (77%, followed by 18% from stacks and cooling towers and 5% from fugitive sources), the focus of this study was on the temporal characterization of flare emissions. Since the petroleum refining industry is a major VOC source in the HGB area according to the 2005 OSD, responsible for 36% of all VOC emissions, followed by chemical manufacturing which is responsible for 28% of all VOC emissions, the study specifically focused on flare emissions associated with refineries and chemical manufacturing plants.

Flare emission profiles were comprised of multiple components including nearly constant, routinely variable, or episodic. Refinery industrial processes that were responsible for the majority of emissions in the 2006 SI were grouped by the type of the industrial process and chemical composition of flared gas into three categories: (1) fuel-fired equipment, process and natural gas flares, (2) fluid catalytic cracking unit (FCCU) flares and (3) unclassified flares. The chemical analysis of these major refinery flare categories revealed that the fuel gas, process and natural gas flares in the 2006 SI emit light gases (propane) and gasoline range volatiles (primarily isobutane and n-butane). Fluid catalytic cracking unit flares typically contained propylene, ethylene, propane, isobutene, and isopentane. VOCs from the “unclassified” flare category included propane, pentane, n-butane, isobutene, propylene, and unclassified VOC.

Within the chemical manufacturing sector, only olefin production processes appeared to have relatively consistent flare emission profiles within the same industrial classification (i.e. SCC). In contrast, flare emissions from other chemical manufacturing facilities showed much greater diversity across similar processes. Thus, this work focused on the characterization of olefin production flares, specifically flares from ethylene production facilities which are responsible for 80% of all olefin production VOC emissions in the 2006 SI. Similar to the approach used for refineries, ethylene production flares were sorted in three categories based on their emissions variability.

The overall objective of the flare emission characterization was to develop more comprehensive input for photochemical air quality modeling and to facilitate the development of more effective emission reduction strategies.

While flaring is the most common method used by refineries, chemical plants, polymer plants and other types of facilities to control emissions of HRVOC, these facilities do have options for controlling routine emissions during normal operation by methods other than flaring. These methods include:

- Process and operational changes that reduce or eliminate discharges to the flare header,
- Recovery of gases in the flare header for reprocessing or use as fuel,
- Use of higher destruction efficiency control devices such as thermal oxidizers during normal operating conditions, and
- Use of staged flares if the control efficiency of a large emergency flare when in routine service is questionable.

What methods may be appropriate for a specific flaring operation must be determined case-by-case. It is reasonable to assume, however, that one or more of these methods could be used to effectively eliminate routine hydrocarbon emissions from flares during normal operating conditions. This assumption does not consider cost or economic feasibility.

The TCEQ and EPA have recently expressed concerns that flares operated at high turndown and/or high steam-to-flare gas ratios may not routinely achieve the assumed control efficiencies. Should planned studies determine that large emergency flares operating under routine loading (i.e. high turndown) do not achieve the assumed control efficiencies, then implementation of the

identified alternative management approaches would result in an even greater reduction in actual emissions.

In addition to routine emissions during normal operation, emissions from flares also result from hydrocarbons being sent to the flare during emission events and during startups, shutdowns and maintenance activities, both scheduled and unscheduled. Opportunities to reduce flaring during these conditions are limited by the need to consider safety and, as with routine emissions, must be evaluated case-by-case.