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Air Sciences

SURVEY OF HRVOC REGULATIONS

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1. INTRODUCTION

Concentrations of ozone in the Houston/Galveston/Brazoria (HGB) area frequently exceed levels specified in the Environmental Protection Agency's ambient air quality standards at 1-hour and 8-hour averaging times. The HGB remains in nonattainment of the 1-hour and 8-hour ozone standards despite implementation of measures designed to reduce emissions of the two major contaminants responsible for formation of elevated ozone: volatile organic compounds (VOCs) and nitrogen oxides (NO_x). Results from the TexAQS 2000 field study (Daum et al., 2002) and more recent studies (Allen et al., 2004; Murphy and Allen, 2004) have shown that short-term releases of highly reactive VOCs (HRVOCs) can explain occurrences of rapid ozone formation and high short-term ozone peaks that have been observed in the HGB. HRVOCs represent a specific group of VOC species that are particularly efficient at producing ozone when mixed with NO_x in sunlight. HRVOCs are released in highly variable but frequently significant quantities from petroleum refining and chemical manufacturing sources in the HGB. These recent research results suggest that control of HRVOC releases is likely to be an important part of an ozone attainment strategy for the HGB.

The 2002 revision of the State Implementation Plan (SIP) for the HGB nonattainment area incorporated regulations to achieve reductions in HRVOCs as part of the strategy to attain the one-hour ozone standard by November of 2007. These regulations focus on four industrial emission sources: fugitives, flares, process vents and cooling towers. In June, 2004, the Texas Commission on Environmental Quality (TCEQ) proposed two revisions to the HGB ozone SIP that would tighten controls on HRVOCs by imposing a short-term limit on HRVOC emissions (proposal 2004-037-115-AI) and initiate a Cap and Trade program to facilitate compliance with annual HRVOC emissions limits (proposal 2004-058-101-AI).

The design of effective and cost efficient VOC controls for ozone attainment should be based on a thorough understanding of the characteristics of different types of VOC sources and the range of potential regulatory mechanisms available for controlling them. This report is intended to contribute to this regulatory knowledge base and thereby inform discussions regarding the formulation of HRVOC control measures for the HGB. Our analysis consists of a summary of the existing and proposed Houston-Galveston HRVOC regulations and a comparison of these regulations with other emission control programs (either targeted specifically at HRVOCs or at VOC emissions in general) that have been implemented or proposed in Texas and other locations both nationally and internationally.

2. REGULATIONS IN THE HOUSTON/GALVESTON/BRAZORIA AREA

As in many ozone nonattainment areas, air quality managers in the Houston/Galveston/Brazoria nonattainment area (HGB NAA) have focused on a combination of NO_x and VOC reductions as the most efficient means of reducing peak ozone concentrations. Achieving the proper balance of VOC and NO_x controls is difficult and conclusions regarding the optimal approach are subject to change over time as improved emission inventories and modeling tools become available. As described in the previous section, recent studies have shown that releases of HRVOCs play an important role in the formation of elevated ozone concentrations in the HGB NAA. As a result, the TCEQ has concluded that it will be more cost-effective to substitute HRVOC control measures for some of the more expensive NO_x control measures included in earlier versions of the HGB ozone SIP. TCEQ's analyses show that limiting emissions of HRVOCs in conjunction with an 80 percent reduction in NO_x is estimated to have the same benefit as a 90% reduction in NO_x alone (TCEQ, 2004b). TCEQ's first round of HRVOC regulations were included in the 2002 SIP and represented one of the first attempts anywhere to focus the control of VOC on a specific set of compounds with the greatest impact on ozone formation. TCEQ is currently proposing revisions to these HRVOC regulations to be included in the current round of SIP revisions. The HRVOC controls implemented in 2002 and the proposed revisions add to previous efforts to control VOC emissions in general from a variety of sources.

2.1. EXISTING HRVOC REGULATIONS IN THE HGB NAA

The 2002 SIP identified several species of HRVOC as contributing disproportionately to the formation of ozone in HGB. Though emitted in lesser quantities than many VOC species, the high reactivity of these species results in their being ranked as the most significant VOC species in terms of ozone formation potential (Figure 2-1). As a result, ethylene, propylene, isomers of butene and 1,3-butadiene were designated as HRVOCs and targeted for reduction. The most important sources of these HRVOCs were found to be petroleum refineries and chemical plants. TCEQ consequently developed a set of regulations designed to reduce emissions from these sources and improve information gathering on the nature, timing, and magnitude of HRVOC releases.

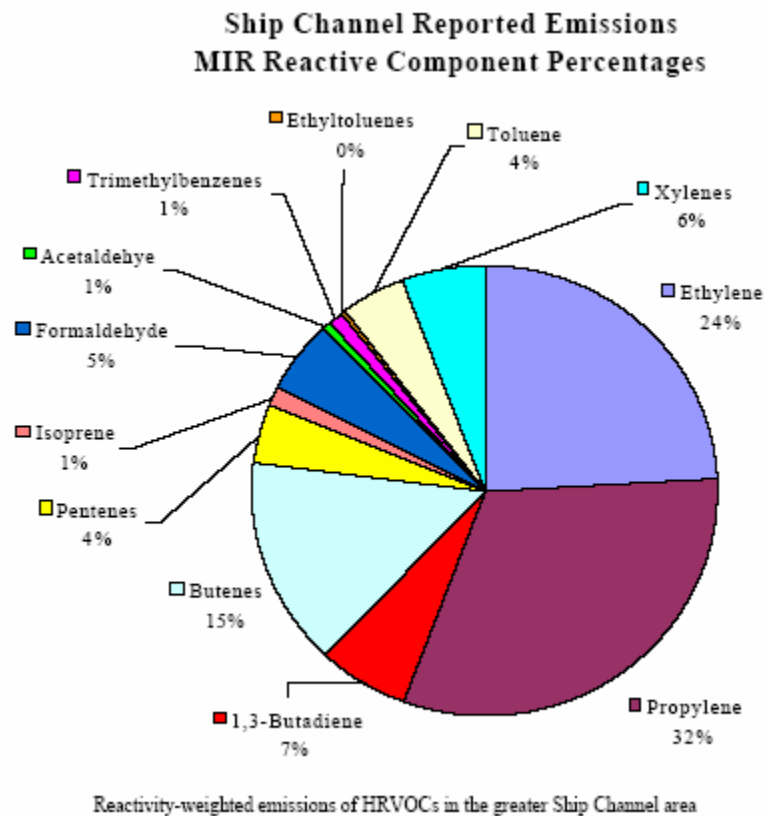


Figure 2-1. MIR-weighted VOC emissions in the Houston Ship Channel area (TCEQ, 2002).

The bulk of the HRVOC regulations included in the 2002 SIP revision were added in a new Subchapter H to Chapter 115 of Title 30, Part I of the Texas Administrative Code. The rules imposed by Subchapter H are summarized in Table 2-1. The sites in HGB subject to Subchapter H are:

- Any [emissions] site with a vent gas stream containing highly-reactive volatile organic compounds (HRVOC) or a flare that emits or has the potential to emit HRVOC (Division 1).
- Any site with a cooling tower heat exchange system which emits or has the potential to emit HRVOC (Division 2).
- Any petroleum refinery; synthetic organic chemical, polymer, resin, or methyl-tert-butyl ether manufacturing process; or natural gas/gasoline processing operation; with a process using HRVOC as a raw material or having an HRVOC as an intermediate or final product or in a waste stream (Division 3) (TAC, 2004).

Table 2-1. HRVOC regulations included in the 2002 HGB SIP.

Applies To:	Requirements	Section	Compliance Date:
Vent gas streams in HGB that have the potential to emit HRVOC	Must continuously comply with 40 CFR 60.18© - (f) when HRVOC is routed to the flare. [Proposed to be amended to 40 CFR 60.18(c)(2) - (6) and (d)]	Chapter 115, Subchapter H, Division 1	For testing requirements, as soon as practicable but no later than December 31, 2004; for other requirements as soon as practicable but no later than April 1, 2006.
	May not use emission reduction credits (ERC) nor discrete emission reduction credits (DERC) to demonstrate compliance.		
	Limited to 24-hour rolling average emission of HRVOC as specified in tables 6-2.1 and 6-2.2.		
	Comply with monitoring and testing requirements including equipping flares with a continuous flow monitoring system.		
	Meet updated record-keeping requirements, including updating hourly the 24-hour rolling average HRVOC emissions for the site-wide cap.		
Any site with a cooling tower heat exchange system (CTHES) in HGB that has the potential to emit HRVOC	Limited to 24-hour rolling average emission of HRVOC as specified in tables 6-2.1 and 6-2.2.	Chapter 115, Subchapter H, Division 2	As soon as practicable but no later than December 31, 2004; with exception of the site-wide cap, for which the deadline is April 1, 2006.
	Meet new monitoring requirements including maintaining a continuous flow monitor on each inlet of each cooling tower and determining the total strippable VOC concentration at a time interval determined by the CTHES capacity.		
	Meet updated record-keeping requirements, including updating hourly the 24-hour rolling average HRVOC emissions for the site-wide cap and keeping hourly records of the emission rate in lb/hr for total strippable VOC, speciated HRVOC and total HRVOC.		
Any process unit or process within a petroleum refinery; synthetic organic chemical, polymer, resin or methyl tert-butyl ether manufacturing process; or natural gas/gasoline processing operation in HGB in which an HRVOC is present.	ID components of each unit which are subject to this division.	Chapter 115, Subchapter H, Division 3	As soon as practicable but no later than December 31, 2003, except in the case of the third-party audit from which results must be submitted no later than December 31, 2004.

Table 2-1. Continued. HRVOC regulations included in the 2002 HGB SIP.

Applies To:	Requirements	Section	Compliance Date:
	Monitor each unit subject to this division in accordance with Division 3 of Subchapter D		
	Adhere to specific monitoring requirements for: recently repaired components, process drains equipped with water-seals, pressure relief valves (PRV), pumps compressors and agitators.		
	Follow new leak repair guidelines including a first attempt at repair for a leak exceeding 10,000 ppmv no later than one business day after the leak is detected and repair accomplished no later than seven days after detection.		
	Upgrade equipment as necessary to reduce emissions of HRVOC; applies to closed-vent systems, control devices and recovery devices, flares, PRV, pumps, compressors and agitators.		
	Adhere to testing requirements including reference method stack testing of components in the LDAR program (for more information on LDAR programs refer to Section 3.2)		
	Enlist a third-party organization to perform an audit every two years of components subject to this division.		

These sources, in addition to the rules described in Table 2-1, are limited to a 24-hour rolling average emission of HRVOC defined in the 2002 SIP revision. An exemption is made by the rule for emissions from scheduled maintenance, startup or shutdown activities (TAC, 2004).

2.2. PROPOSED 2004 SIP REVISIONS TO CHAPTER 101

In the course of preparing the 2004 revisions to the HGB ozone SIP, TCEQ determined that replacing certain high cost NO_x control programs with additional HRVOC controls would represent a more cost effective approach to achieving attainment. As a result, two major changes to the HRVOC regulations have been proposed for adoption (TCEQ, 2004a; TCEQ, 2004b):

1. Implementation of a short-term “not to exceed” limit.
2. Replacement of the site caps in the 2002 SIP with a new HRVOC Cap and Trade Program to be defined in the new Division 6 of Subchapter H, Chapter 101.

Short-Term Limit

A short-term not to exceed limit of 1,200 lbs over a one hour period is proposed to address HRVOC emissions that result from process upsets, process turn around, startup and shutdown activities. This limit would replace the 24-hour rolling average limit included in the 2002 rulemaking and remove existing exemptions for maintenance, startup and shutdown activities.

Cap and Trade Program

Under the proposed cap and trade program, the total allowable emissions of HRVOCs would be less than those allowed under current rules. For the purposes of defining emissions allowances, the Houston region would be divided into two areas: 1) Harris County and 2) the surrounding counties that make up the rest of the HGB nonattainment area (Brazoria, Chambers, Fort Bend, Galveston, Liberty, Montgomery and Waller Counties). These two regions are shown in Figure 2-2. In Harris County, allowances would be allocated for 1,3-butadiene; all isomers of butene, ethylene; and propylene whereas in the surrounding seven counties allowances would be allocated for just ethylene and propylene. 1,3-butadiene and isomers of butene are not proposed to be controlled outside of Harris County. One “allowance” would authorize the holding facility to emit 1/10 of one ton of any combination of the controlled HRVOCs (TCEQ, 2004a).



Figure 2-2. Houston/Galveston/Brazoria HRVOC cap and trade regions.

Under TCEQ's proposal, allowances would be allocated based on each source's baseline activity. There would be three pools from which allowances would be allocated to three distinct categories of sources: refineries, other industries that use HRVOC in a process and sources that do not include process units that produce or use an HRVOC. These categories are designed to deal with the different ways in which different industries' baseline activity reflect their potential to emit HRVOC (TCEQ, 2004c).

Within each category, each source would receive an allocation of that category's pool based on the percentage of the source's baseline activity relative to the total baseline activity of all sources within the same category and region (the two regions being 1. Harris County and 2. the surrounding seven counties shown in Figure 2-2). In this rule, baseline activity is defined as the amount of HRVOC produced as an intermediate, byproduct or final product or used by a process unit that is not recycled internal to the process unit (TCEQ, 2004a). For those industries that do not include process units that produce or use an HRVOC, allowance shares would be determined by the percentage of a source's throughput or storage of HRVOC.

The size of the allowance pool for sites that do not include process units that produce or use an HRVOC would be ten percent of the total HRVOC emissions modeled in the attainment demonstration, not including those HRVOC emissions modeled for refineries. Sites that use an HRVOC in a process unit, but are not a refinery would share the remaining 90 percent. The non-refinery HRVOC emissions under the modeled attainment scenario are 2,240.8 tons per year (tpy) in Harris County and 3,085.4 tpy in the surrounding seven counties. The refinery category's pool of allowances would be based upon the total HRVOC emissions modeled for refineries in the attainment demonstration (770.2 tpy in Harris County, 1,489.3 tpy in the seven surrounding counties). The size of each of the pools of allowances is summarized in Table 2-2.

Table 2-2. Distribution of HRVOC emission allowances under the proposed cap and trade program (source: TCEQ, 2004c).

	Category	Harris County	Seven Counties
1	Sites including HRVOC in a process that are not refineries	At least 90% of 2,240.8 tpy	At least 90% of 3,085.4 tpy
2	Sites not including HRVOC in a process	Up to 10% of 2,240.8 tpy	Up to 10% of 3,085.4 tpy
3	Refineries	770.2 tpy	1,489.3 tpy

Additional provisions of the Cap and Trade Program are (TCEQ, 2004c):

- The penalty for emitting more HRVOC than a site holds allowances for would be a reduction of that site's allowances in the following period by 110% of the emissions in excess of allowances.
- Allowances will be deducted from a site's account on March 31st of the year following the compliance period.
- Allowances may be banked for future use or traded during the control period for which they are allocated or the following control period.
- Each site must submit an Annual Compliance Report, which must include the total amount of HRVOC emissions from each covered facility at the site and a summary of all final trades.
- Each site must submit a Level of Activity Certification Form defining their baseline level of activity no later than April 30, 2005.
- Sites emitting less than 10 tpy of HRVOC are exempt from the program.
- Initial control period of April 1, 2006 through December 31, 2006.

Additional Revisions

In addition to the Cap and Trade Program, there are numerous minor changes proposed that modify monitoring and reporting requirements. These are summarized in Table 2-3.

Table 2-3. Additional revisions to HRVOC regulations in the proposed 2004 SIP revision (source: TCEQ, 2004e).

Section	Change
115.725(a)	PRVs exempted from testing as vent gas streams. Other vent gas streams not controlled by a flare must be tested and operating parameters established to ensure compliance with the site-wide cap.
115.725(c)	Defines monitoring requirements for pressure relief valves.
115.725(d)	Defines continuous monitoring requirements for affected flares.
115.725(e)	Specifies distinct requirements for flares used for the abatement of emissions from marine/transport vessel loading and unloading operations.
115.725(f)	Monitoring requirements for flares used solely for the abatement of emissions during maintenance or startup/shutdown are defined.
115.725(g)	Monitoring requirements for emergency flares (from process upsets) specified.
115.725(h)	Monitoring requirements described for temporary flares, other than those addressed in 115.275(f) and 115.725(g).
115.725(i)	Methods are assigned for determining compliance of flares that receive liquid or dual phase streams containing HRVOC.
115.725(j)	Specific requirements described for flares controlling vent gases from metal alkyl production processes.
115.725(k)	Special requirements identified for flares in multi-purpose service (e.g. both emergency and startup/shutdown service).
115.726	Specifies recordkeeping requirements that reflect the changes in PRV and flare monitoring.
115.766	Allows greater flexibility in the sensitivity of monitoring equipment for cooling towers.
115.780	One cannot use emission reduction credits or discrete emission reduction credits to comply with HRVOC fugitive emissions rules.
115.788	3 rd party audit frequency changed from all process units every two years to at least one process unit per year and all units within a five year period.

2.3. OTHER TEXAS REGULATIONS AFFECTING EMISSIONS OF HRVOCs

As mentioned previously, greater control of VOC emissions in lieu of certain costly NO_x reduction programs has gained increased attention in recent years as a more cost-effective way of achieving ozone attainment in Houston. In addition to the HRVOC regulations summarized above, sources in the HGB are subject to a wide variety of VOC control measures. These more traditional control measures target VOC emissions in general and are not specific to HRVOCs but they nevertheless contribute to overall HRVOC emission reductions. We therefore provide here a brief description of these traditional VOC control programs. Also worth noting is the emissions reporting rule adopted in 2000 which is directed at record keeping and the dissemination of information about VOC emissions. This rule addresses those process upsets which appear to be correlated with ozone exceedances and is therefore directly relevant to HRVOC emissions. Finally, we also mention here steps currently being taken in Northeast Texas to reduce industrial emissions of HRVOC. Although of a more limited scope than those in HGB, this effort targets some of the same kind of HRVOC sources found in the HGB area.

Traditional VOC Control Measures

Texas has many rules to limit emissions of all types of VOC. A list of these rules is provided in Appendix A. An analysis of the degree to which these control measures limit HRVOC emissions is beyond the scope of the present study. However, HRVOC emissions in the routine point source inventory represent roughly 14% by weight of total VOC emissions within the HGB area (Murphy and Allen, 2004) so these traditional VOC measures can be expected to have a reasonably significant effect on routine HRVOC emissions, especially at facilities where HRVOCs are created or used in large quantities. Regulations limiting VOC emissions from petroleum refining operations (found in 30 TAC Chapter 115, Subchapter D) as well as generic controls for other types of sources (VOC storage, loading and unloading, etc.) are particularly important in this regard. Nevertheless, as demonstrated in technical analyses accompanying the 2004 SIP revision, high ozone levels in HGB can often be traced back to remaining releases of HRVOCs from petrochemical sources: wind direction analyses indicated that emissions from the cluster of industrial sources along the Houston Ship Channel in particular contribute to high ethylene and propylene concentrations associated with rapid ozone formation (TCEQ, 2004d). In other words, existing generic VOC control measures have been found to be insufficient to adequately limit the types of emissions that frequently drive high ozone events in the HGB NAA.

Emissions Reporting Rule (Texas 30 TAC 101)

In 2000, Texas adopted legislation to require reporting of emissions resulting from process upsets and maintenance, startup and shutdown activities. These rules built upon the concept established in the Federal Emergency Planning and Community Right-To-Know Act (EPCRA) of using threshold reportable quantities (RQ) to determine when a source must report an emission (EPA, 2000). The RQs for several VOC in the HGB and BPA nonattainment areas were defined as (TAC, 2004b):

- Butenes = 100 lbs
- Ethylene = 100 lbs
- Propylene = 100 lbs
- Acetaldehyde = 100 lbs

- Toluene = 100 lbs

These rules do not require formulation of a risk management plan and do not directly result in emission reductions; although the presence of the reporting requirement may promote improved process operations resulting in fewer reportable releases. Risk management plans are required by the Federal Emergency Release Rule (see discussion in Section III).

Northeast Texas Early Action Compact (EAC)

As part of the Northeast Texas EAC strategy for attainment of the 8-hour ozone standard by December 31st, 2007, both the Texas Eastman and Huntsman chemical manufacturing facilities in Gregg County have entered into a voluntary agreement under which they will implement a leak detection and repair (LDAR) program that is more stringent than normally required for facilities in this region. This enhanced LDAR program has been specifically designed to reduce emissions of HRVOCs. Modeling analyses prepared in support of the development of the EAC show that the projected HRVOC emission reductions achieved by the enhanced LDAR program are expected to reduce the 8-hour ozone design value at Longview by 0.1 ppb in 2007 (NETAC, 2004).

3. REGULATIONS IN OTHER JURISDICTIONS

We conducted a review of HRVOC regulations at the Federal level, in other states and in other countries around the world. Results from our review indicate that Texas is at the forefront of this particular approach to controlling ozone precursors. In the US, only California and Louisiana have rules that explicitly acknowledge the importance of reactivity in the formulation of VOC emission control programs. Louisiana, building upon the work that has been done within the HGB NAA, recently passed a rule designed to gather more information on the importance of releases of HRVOC in Baton Rouge. In California, a rule has been adopted to restrict the reactivity of VOCs used in aerosol coatings. Aside from these examples of reactivity-based controls, several Federal and state programs have been developed to control emissions from industrial episodic releases and fugitive emissions from industrial sources, which in many cases are likely to consist in part of HRVOCs. Although these regulations do not specifically target HRVOCs, they can be expected to result in HRVOC emission reductions.

3.1. REGULATIONS TARGETING HIGHLY REACTIVE VOCs

Louisiana HRVOC Reporting Rule

The Louisiana Department of Environmental Quality (LADEQ), upon observing spikes in HRVOC concentrations prior to ozone exceedance episodes similar to those observed in HGB, has implemented a reporting rule that applies to emissions of HRVOC. This rule requires reporting episodic releases from any source that exceed 100 pounds of HRVOC (the LADEQ defines HRVOCs to include acetaldehyde, butenes, ethylene, propylene, toluene, xylene and isoprene; see LADEQ, 2004b). Further monitoring is underway and additional regulation of HRVOC may be developed if the studies find that targeted HRVOC reduction measures represent an effective means of reducing ozone formation (Hazlett, 2004). Louisiana's governor recently issued administrative orders requiring 16 facilities in the Baton Rouge area to conduct routine fence-line air monitoring targeted at HRVOC releases. The governor also ordered six of the facilities to prepare detailed emission audits. More information about on-going studies in the Baton Rouge area is available from the Baton Rouge HRVOC Work Group's website (<http://www.deq.state.la.us/evaluation/ozone/otcintro.htm>).

California Aerosol Coating MIR Weighted Limits

The only other regulation identified by this study which specifically targets HRVOCs is a California regulation designed to reduce aerosol coating product emissions (CARB, 2004). This regulation specifies a product-weighted maximum incremental reactivity (MIR) allowable for various coating products sold in California. The list of VOCs required by the rule to be included in the MIR weighted total is extensive and includes the HRVOCs regulated under the new HGB rules (1,3-butadiene, isomers of butene, ethylene and propylene).

Using a reactivity-based limit for aerosol coatings enabled CARB to achieve the same ozone reduction benefit as placing a mass-based VOC limit on formulations while allowing coating manufacturers more flexibility. The rule was required by previous legislation to attain an ozone

reduction benefit equivalent to that achieved by reducing total VOC emissions from this source by 3.1 tons per day (CARB, 2000). As a rough estimate, the potential impact in HGB that this rule would achieve can be estimated using population as a surrogate activity factor for aerosol coating use as is typically done for consumer product sources (EIP, 1996). Applying the ratio of HGB population to California population (4.9 M to 35 M) to the 3.1 tpd estimated equivalent VOC reduction results in an estimated equivalent total VOC reduction in the HGB of 0.44 tpd. An average aerosol coating product formulation was not reported in the background documents prepared for the California rulemaking so the fraction of the estimated 0.44 tpd VOC emissions that are HRVOCs is not known. In any event, total HRVOC emissions from this source are very small in comparison to the 19 tpd of HRVOCs emitted from HGB point sources (Murphy and Allen, 2004).

In addition to the aerosol coating legislation, California's Clean Fuel/Low Emissions Vehicle regulations use MIR values of exhaust species (Carter et al, 1997) to compare Clean Fuel/Low Emissions Vehicle emissions with those of traditional vehicles (CCR, 2004b). Reactivity-based adjustment factors were developed based on the MIR values of exhaust species. These adjustment factors are used to develop mass-based emissions standards for clean fuel vehicles that are equal, based on ozone forming potential, to the standards for traditional vehicles. This legislation was enacted in the early 1990s, representing an early example of the explicit use of VOC reactivity in an emission regulation.

3.2. VOC REGULATIONS

A number of regulatory programs focus on VOC emissions from sources that can be expected to have significant quantities of HRVOCs included in their emissions streams. Of particular interest are fugitive emission control programs, programs dealing with episodic emergency releases, and other programs, including a new refinery waste water program currently under consideration in the San Francisco Bay Area that focus on the types of industrial sources typically associated with HRVOC releases. Most of these programs have also been implemented in some form in the HGB NAA.

Fugitive Emission Control Programs

A Federal Leak Detection and Repair (LDAR) program is mandated by the New Source Performance Standards in 40 CFR Part 60. These standards apply to fugitive emissions at all new petroleum refineries, synthetic organic chemicals manufacturing facilities, and onshore natural gas processing plants (CFR, 2004). In addition, these and many other sources are regulated by the National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements under 40 CFR Part 61 and 40 CFR Part 63. Under the NESHAP requirements, a process unit at one of the regulated sources that uses or produces a hazardous air pollutant (e.g. benzene or 1,3-butadiene) is subject to stringent requirements, including the LDAR program specified in 40 CFR 61.240-247. The LDAR programs set forth in 40CFR60 and 40CFR63 have similar requirements. Among those requirements are:

- Pumps and valves must be inspected monthly [once per week under NESHAP requirements]. After two monthly inspections without leaks, they may be inspected quarterly until a leak is detected.

- Leak threshold at 10,000 ppm for pumps, valves and connectors. Compressors required to have a seal system with barrier fluid. PRDs in heavy liquid service leak threshold at 10,000 ppm, in gas/vapor service at 500 ppm.
- Leaks > 10,000 ppm 15 day repair maximum, first attempt within 5 days.
- Submit semiannual reports containing the number of components, by type, that were repaired and for which repair was delayed and reason for delay.
(adopted from BAAQMD, 2003)

States have the option to implement more stringent LDAR programs. Among the agencies that have done so are the (San Francisco) Bay Area Air Quality Management District (BAAQMD, 2004), the South Coast (Los Angeles) Air Quality Management District (SCAQMD, 2002), and the Texas Commission on Environmental Quality (TAC, 2004). All of these programs include the same basic elements required by the Federal rule: sites must identify components that are subject to the rule, routine monitoring of those components must be conducted, any leaking components must be repaired and monitoring results must be reported (EPA, 1999).

The most significant variations on the Federal rule employed by some states are in the threshold mandated for defining leaks and in the period allowed for repairing leaks. The BAAQMD program has the most stringent leak standards. The threshold for identifying leaks under the BAAQMD Rule 8-18 is 100 ppm for valves and connectors and 500 ppm for pumps, compressors and PRDs in gas/vapor/light liquid service. When identified, leaks must be minimized within 24 hours and repaired within 7 days. The allowance made for Non-repairable Equipment¹ in the BAAQMD rule is only 0.30% of the total number of valves, as compared to the Federal allowance of 2.0% (BAAQMD 2003).

In terms of severity, the LDAR standards imposed on refineries and chemical producers in HGB by 30 TAC §115.352 fall between the Bay Area and federal rules. The leak threshold for valves and connectors in VOC service is 500 ppm and 10,000 ppm for pumps and compressors. When a leak is detected repair must be attempted within five days and completed within 15. Exceptions are made for repairs that would require process shutdown so long as it is shown that a process shutdown would result in more emissions than the leak (TAC, 2004b).

Provisions of 30 TAC §115.352 refer to the controls in Chapter 115, Subchapter H for components in HRVOC service. TCEQ Chapter 115, Subchapter H, Division 3, though limited in application to HRVOC, is in other aspects similar to other LDAR programs. The TCEQ rule defines the threshold for leaks at 500 ppm as methane for all components. For leaks detected over 10,000 ppm, a first attempt at repair is required within one business day of detection and repair must be completed no later than seven days after detection. For leaks of less than 10,000 ppm, a first attempt must be made within five days and repair completed within 15. Repairs may be delayed if the component does not remain in HRVOC service, if repair would require a shutdown resulting in more emissions than the leak or in certain cases of pumps, compressors or agitators. These allowances do not extend to valves, for which repair cannot be delayed unless "extraordinary efforts" have failed or cannot be applied due to safety considerations (TAC, 2004). Division 3 of the TCEQ HRVOC regulation includes additional guidance on equipment types and required control efficiencies. A summary of this rule was presented in Section II above (see Table 2-1).

¹ All LDAR programs reviewed have some provision for equipment that cannot be repaired without shutting down the process.

Episodic Emergency Releases

TCEQ's HRVOC rule proposal solicits comments on ways to mitigate violations of the short-term emissions cap. Unplanned emissions from industrial facilities have been identified as potentially important sources of HRVOCs and initiatives aimed at reducing the frequency and magnitude of unplanned emissions are being made at the Federal and state level by government and industry groups. As described in more detail below, a variety of approaches are being taken. EPA's Episodic Release Reduction Initiative focuses on finding and correcting the root causes of unplanned events. The focus of regulations passed by California air districts has been on controlling the emissions from flaring that occurs as a result of these events. Finally, both state and Federal regulations exist which seek to control the most dangerous toxic and flammable releases through risk management and prevention planning.

Root Cause Analysis of Episodic Releases

A 2001 report on the EPA-Industry *Episodic Release Reduction Initiative* collected and analyzed data on root causes of VOC release events and examined best practices and procedures for limiting the number and magnitude of releases (EPA et al, 2001). This initiative represents an example of cooperation between industry and regulators in identifying the causes of episodic releases so that they may be reduced in the future. Some of the causes identified by the initiative were equipment failure and startup/shutdown. Beyond the list of common root causes of episodic releases, this study is valuable in that it demonstrates a process by which industry groups can cooperatively gather information, identify common problems, and share strategies for reducing emissions (EPA et al, 2001).

Flare Rules

In response to new data on air contaminant releases from flares which indicate that flare emission rates are significantly higher than had generally been assumed, the BAAQMD recently passed rule 12-11 which calls for detailed monitoring and reporting of flaring. This rule calls for continuous monitoring of vent gas flow rate and sampling of the composition of vent gases on each day that flaring occurs. Operators of flares subject to this rule must submit a monthly report containing the hourly vent gas flow rate and sampling results (BAAQMD, 2004b).

The SCAQMD has had a similar rule in place for refinery flares since 1998. The monitoring requirements of the SCAQMD rule are detailed in Table 3-1. Results of this monitoring must be submitted quarterly.

Table 3-1. Monitoring and record keeping requirements under the SCAQMD flare rule.

TYPE OF FLARE	OPERATING PARAMETER	MONITORING AND RECORDING
Clean Service	Gas Flow ¹	Measured and Recorded ² Continuously with Flow Meter(s) and/or On/Off Flow Indicator(s)
	Gas Heat Content ³	Calculated or Representative Sample for Each Flare Event ⁴
	Total Sulfur Content	Calculated or Representative Sample for Each Flare Event ⁴
Emergency Service	Gas Flow ¹	Measured and Recorded ² Continuously with Flow Meter(s) and/or On/Off Flow Indicator(s)
	Gas Heat Content ³	Representative Sample for Each Recordable Flare Event ⁴
	Total Sulfur Content	Representative Sample for Each Recordable Flare Event ⁴
General Service	Gas Flow ¹	Measured and Recorded ² Continuously with Flow Meter(s) with or without on/off flow indicator(s)
	Gas Heat Content ³	Representative Sample for Each Recordable Flare Event ⁴
	Total Sulfur Content	Representative Sample for Each Recordable Flare Event ⁴

(SCAQMD, 1998)

Flares, if not regulated by state rules, fall under the Federal rule 40 CFR 60.18(c) - (f). Under this rule, flares must be operated with a flame present at all times and are allowed a maximum of five minutes of visible emissions during any 2 consecutive hours. In addition, the rule specifies numerous requirements of vent gas quality and flare operating parameters for different types of flares (CFR, 2004b). The Texas flare rule (30 TAC 111.111) imposes the same limitations as the Federal flare rule (TAC, 2004b).

Risk Management Plans

Section 112(r) of the Clean Air Act directed the EPA to produce regulations to minimize risks associated with the accidental release of hazardous chemicals from industrial operations. The rules that resulted are found in 40 CFR 68. Propylene, butene and 1,3-butadiene are all classified as hazardous chemicals under this rule. If a facility has over 10,000 lbs of any one of these substances in a process, then it must adhere to the Federal Chemical Accident Prevention Provisions (EPA, 2001).

Formulating a risk management plan is one element of the Federal Chemical Accident Prevention Provisions. This plan must include (EPA, 2001):

- An offsite consequence analysis
- A 5-year history of accidental releases
- An integrated prevention program to manage risk
- An emergency response program

- An overall management system to supervise the implementation of these program elements.

Under 40 CFR 68, refineries and chemical manufacturers are subject to what are called Program 3 requirements. Under Program 3 requirements, in order to further diminish the potential for an accidental release of hazardous chemicals these facilities must create a prevention program that includes (EPA, 2004):

- Process Safety Information - This includes information about the physical properties and hazards presented by the compound, information on the process technology and equipment.
- Process Hazard Analysis - Covers the potential hazards of the process, controls applicable to the hazards, consequences of a failure of controls or human error.
- Operating Procedures - Describes the steps for initial startup, normal operations, temporary operations, unplanned operations, etc. Also describes precautions and control measures to be employed.
- Mechanical Integrity - Establishes procedures for maintaining the integrity of equipment including an inspection and testing program and a repair strategy.

One effect of the Federal rule may have been to encourage facilities to use less of these chemicals in processes so that they would fall below the thresholds (Kleindorfer et al, 2002). In general, it would be difficult to identify the impact that 40 CFR 68 has had on the release of HRVOC. Propylene, butene and 1,3-butadiene are listed as hazardous chemicals due to their flammability rather than their ozone-forming potential. Though the same types of program elements involved in the Chemical Accident Prevention Provisions could be employed to diminish accidental releases of HRVOC, one cannot simply assume that methods employed to prevent explosions of these flammable gases have significantly reduced the emissions that lead to ozone formation in HGB.

The State of California has imposed its own emergency release legislation referred to as the California Accidental Release Prevention Program (CalARP) regulations. CalARP is very similar to the EPA's program. The most significant differences between the two programs is that the CalARP list of toxic chemicals includes 276 chemicals where the EPA list includes only 77 and the threshold quantities of toxic substances that a site must have to fall under the requirements of the program are frequently smaller under CalARP. The CalARP program also requires that an external events analysis be performed, including a seismic analysis (CCHS, 2004). For HRVOCs, however, the CalARP threshold quantities were set equal to those in the Federal rule and so HRVOCs do not receive substantially stricter treatment under CalARP (CCR, 2004).

Additional Control Programs of Interest

Another source of VOC emissions that has been targeted by local and Federal programs is refinery wastewater collection systems. While these systems typically emit a variety of VOC species, including benzene, EPA's speciation profile for fugitive emissions from refinery covered drainage / separation pits does not include any HRVOCs.

The BAAQMD is in the final stages of adopting a regulation designed to further reduce emissions from this source. The BAAQMD regulation would impose the following requirements on the system of process drains, trenches, manholes, junction boxes, reaches, sumps and lift stations that channel wastewater around a refinery:

- Refineries would have to install controls on components of the system found to be leaking VOC in excess of 500 ppm.
- Refineries would have to perform inspection and maintenance programs to ensure that standards are met.
- Refineries would have to maintain documentation of the inspection and maintenance programs.

The BAAQMD estimates that, if adopted, the new regulation would reduce refinery wastewater system VOC emissions by 65% - equivalent to 2.1 tons per day (BAAQMD, 2004c).

The Bay Area rule essentially constitutes a more stringent version of similar existing Texas and Federal regulations. The Federal NSPS and NESHAP requirements include control of VOC emissions from refinery wastewater systems. However, the Federal controls are only imposed on new sources or sources with significant (greater than 11 ton/yr) emissions of benzene (CFR, 2004d). The NSPS controls, specified in 40 CFR 60.692-693, require water seals on drains, covers on junction boxes and sewer lines and additional control measures on oil-water separators (CRF, 2004). The NESHAP rules include controls designed to reduce emissions of benzene (40 CFR 61.340-359) from many facility types and of HAPs generated at organic chemical production facilities (40 CFR 63.133-137). NESHAP controls include drain system and oil-water separator controls similar to those in the NSPS as well as seals or emission control devices on tanks, impoundments and containers (CFR, 2004c; CFR, 2004d).

Since 2001, 30 TAC §115.142 has required control of VOC emissions from wastewater systems at industrial facilities in HGB. The Texas rule is applicable to a large group of industries including organic chemical manufacturing, petroleum refining and pesticide manufacturing. Apart from its wide applicability, it is similar to the Federal rules in the seals and vapor controls that it requires. Under the Texas rule, 90 percent of the VOC must be removed from any wastewater stream containing greater than 1000 ppm VOC before the wastewater is exposed to the air (TAC, 2004b). Though information on the effectiveness of the HGB controls could not be found, it would appear that most of the controls proposed in the BAAQMD wastewater rule have already been implemented in HGB. The main distinctions between the Texas, Federal and Bay Area rules are the 500 ppm definition of a leak requiring a control measure proposed in the Bay Area rule and the exemptions. The Federal NESHAP rule exempts sources with less than 11 ton/yr HAP (benzene) emissions and the Texas rule exempts sources with an annual VOC loading of 11 ton/yr or less in the wastewater stream while the Bay Area proposed rule would have no similar lower limit for applicability at refineries (TAC, 2004b; BAAQMD, 2004c).

3.3. INTERNATIONAL REGULATIONS

An informal review of VOC regulations outside of the U.S. was undertaken in an attempt to identify any jurisdictions in which emission control programs focused specifically on reductions of HRVOCs have been implemented or are currently under consideration. Results for the major industrial regions of the world are briefly summarized below.

Canada

Canadian VOC emission regulations were reviewed to identify any that specifically targeted HRVOCs but no such rules were found. Some VOC reduction programs exist in Canada (see <http://www.ec.gc.ca/air/>), including a memorandum of understanding with the Canadian Chemical Producers' Association (CCPA). This memorandum of understanding represents a voluntary effort on behalf of CCPA members to reduce emissions of VOC through a program termed Responsible Care®. This program does not prescribe specific VOC reduction measures. Instead, it estimates VOC reductions attainable by producers and outlines a framework for cooperation between producers and provincial and national government agencies to facilitate achievement of those reductions (Environment Canada, 2002). HRVOCs are not specifically addressed by the memorandum of understanding. In response to our inquiries, representatives of Environment Canada confirmed the absence of any Canadian programs specifically targeting HRVOCs (Leah, 2004; Kuper, 2004).

Europe

Emissions from major industrial sources in the European Union are regulated by Annex I of the Integrated Pollution Prevention and Control (IPPC) Directive. As in the U.S., these sources are required to obtain operating permits and emissions are subject to Best Achievable Technologies (BAT) as defined in Annex IV. For existing (unmodified) facilities, BAT requirements are being phased in over an 11 year period (1996 – 2007); sources in new EU member states must comply by 2012. Some sources were previously permitted under a BAT requirement dating to a 1984 EU directive. In addition to BAT requirements under the IPPC, the EU has major VOC control programs in place for Stage I vapor recovery and solvent use.

A survey of the state of fugitive VOC control programs in Europe was prepared for the European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL, 2004). This survey dealt with fugitive VOC controls in general; there was no specific emphasis or information on HRVOC release events. In general, the findings of this survey show that fugitive VOC control programs are not as well developed in Europe as in the U.S. although efforts are underway to improve standards and practices.

A survey of environmental regulation experts in ENVIRON's European offices (located in Finland, France, Germany, Italy, The Netherlands, and the United Kingdom) did not turn up any regulatory programs focused specifically on HRVOCs.

Asia

ENVIRON air quality consultants in China, Singapore and Australia were contacted to determine the existence of any HRVOC programs in the region. While air emission control programs are in place in the Philippines, India, Indonesia, Thailand, Singapore, Malaysia, South Korea, China and Australia, none of these programs specifically target HRVOCs (Bell, 2004; Zhou, 2004; Ding, 2004).

4. CONCLUSIONS

Our review of emission control regulations outside of Texas indicates that the current and proposed HRVOC regulations for Houston/Galveston/Brazoria (HGB) represent the forefront of such control programs. While several other jurisdictions representing ozone nonattainment areas with significant petrochemical sources are paying increasing attention to the potential role in ozone formation of episodic VOC releases in general and HRVOC releases in particular, no other program has yet set limits specifically targeting a small group of HRVOC species based on their ozone formation potential. This is not to say that the Texas HRVOC regulations are not without any precedence: California previously turned to reactivity-based formulations for control of aerosol coating and motor vehicle emissions and the importance of regulating VOCs on a reactivity weighted basis was explicitly acknowledged during debate on the 1990 Clean Air Act Amendments.

Some elements of other local and national programs are similar to the HGB HRVOC regulations. The U.S. EPA is working with industry to advance leak detection and repair efforts and to find solutions to minimizing episodic releases. Air managers in Louisiana are taking steps to improve reporting of episodic emission events. Air districts in California are tightening controls on flares and non-traditional sources of fugitive emissions. The cooperative efforts led by the EPA and the regulations in California both offer useful guidance for controlling emissions of VOCs from industrial sources, but without being specific to HRVOCs.

Existing and proposed HRVOC control measures for the HGB area target those source sectors that represent by far the major actual and potential sources of HRVOCs in the region. While other VOC sources (e.g., other processes such as refinery waste water systems and other source sectors such as consumer products, etc.) also represent potential sources of HRVOCs, the quantities of HRVOCs from these sources involved in ozone exceedance events that are amenable to HRVOC targeted controls is likely to be very small. Results from photochemical modeling analyses (Allen et al., 2004) have shown that HRVOC releases on the order of 100 to 1,000 lbs/hr can result in increases in peak ozone concentrations in the HGB area under certain circumstances. Temporally and spatially isolated HRVOC sources of this magnitude are in all likelihood limited to the refinery and chemical industry sources targeted by the HGB HRVOC regulations. Our review found no evidence to suggest the existence of any other source sectors associated with these types of HRVOC releases that might represent suitable targets for additional HRVOC regulation.

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APPENDIX A

VOC EMISSION CONTROL REGULATIONS IN TEXAS

APPENDIX A: VOC Emission Control Regulations in Texas

VOC Rules, Chapter 115	Purpose
Subchapter B, Division 1	Control emissions from storage of VOC.
Subchapter B, Division 2	Control vent gases containing VOC with an efficiency of 90% or to no more than 20 ppmv.
Subchapter B, Division 3	Control emissions from VOC water separators.
Subchapter B, Division 4	Control emissions from industrial wastewater.
Subchapter B, Division 5	Control emissions from municipal solid waste landfills
Subchapter B, Division 6	Control emissions from batch processes
Subchapter C, Division 1	Control emissions from loading and unloading of volatile organic compounds
Subchapter C, Division 2	Control emissions from filling of gasoline storage vessels for motor vehicle fuel dispensing facilities
Subchapter C, Division 3	Control of VOC leaks from transport vessels
Subchapter C, Division 4	Control of vehicle refueling emissions at motor vehicle fuel dispensing facilities
Subchapter C, Division 5	Control of Reid vapor pressure of gasoline.
Subchapter D, Division 1	Control VOC emissions resulting at petroleum refineries from process unit shutdown or turnaround. Control resulting vent gases to 90% or 20 ppmv. Also defines the sources subject to Subchapter H
Subchapter D, Division 2	Control fugitive VOC emissions from petroleum refining in Gregg, Nueces and Victoria Counties.
Subchapter D, Division 3	Control fugitive VOC emissions from petroleum refining in ozone nonattainment areas.
Subchapter E, Division 1	Control emissions from degreasing.
Subchapter E, Division 2	Control emissions from surface coating.
Subchapter E, Division 3	Control emissions from flexographic and rotogravure printing.
Subchapter E, Division 4	Control emissions from offset lithographic printing.
Subchapter F, Division 1	Control emissions from the use of cutback asphalt.
Subchapter F, Division 2	Control emissions from pharmaceutical manufacturing facilities.
Subchapter F, Division 3	Control emissions from the degassing or cleaning of stationary, marine and transport vessels.
Subchapter F, Division 4	Control emissions from petroleum dry cleaning systems.
Subchapter G, Division 1	Control emissions from windshield washer fluid.
Subchapter H	Relates to HRVOC (see Table 1 in main report).

Source: TAC (2004)