VALERO
REFINING COMPANY-CALIFORNIA

Flare Minimization Plan
Regulation 12-12
Benicia Refinery

Public Information

Revision 13.0

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1. Executive Summary

1.1 BAAQMD Regulation 12, Rule 12 Overview

On July, 20, 2005, the Bay Area Air Quality Management District's (BAAQMD) Board of Directors adopted Regulation 12-12. The BAAQMD's stated objectives for the rule were and are to minimize the frequency and magnitude of flaring events at petroleum refineries, and therefore reduce emissions (Regulation 12-12-101). However, despite these objectives, the BAAQMD made clear that nothing in the rule should be construed to compromise refinery operations and practices with regard to safety (Ibid.).

It is worth stressing that with regard to safety the BAAQMD recognized that because flares are first and foremost safety devices that must be available at all times for use in various situations to prevent accident, hazard, or release of refinery gas directly to the atmosphere, the formulation of a rule that will minimize the frequency and magnitude of flaring events at petroleum refineries, and therefore reduce emissions, must provide refineries with flexibility to address their unique flare systems without compromising the safety of workers and the public or the refineries.

To achieve the BAAQMD's objectives of minimizing the frequency and magnitude of flaring events, the rule prohibits flaring except for emergencies and as necessary to prevent an accident, hazard, or release of vent gas directly to the atmosphere, unless it is consistent with an approved Flare Minimization Plan (FMP) and all commitments due under that plan have been met (Regulation 12-12-301).

The rule requires that by August 1, 2006, the owner or operator of a petroleum refinery with one or more flares subject to this rule shall submit a FMP as required by Regulation 12-12-401 (Regulation 12-12-402). Regulation 12-12-401 indicates that the elements of an FMP[1] include:

1. A description of and technical information for the refinery flare system and the upstream equipment and processes that send gas to the flare, including all associated monitoring and control equipment;
2. A description of the equipment processes and procedures previously installed or implemented by the owner or operator within the last five years to reduce the flaring;
3. A description of any equipment, process or procedure to reduce flaring that is planned, but not yet installed or implemented and the schedule for completion; and

[1]The BAAQMD has emphasized that an FMP is not intended to serve as a permit for a flare or to be included as part of the refinery permit, and therefore, the plan is not subject to provisions of the Health and Safety Code or BAAQMD rules related to permits.

- safety – to prevent an accident, hazard, or release of vent gas directly to the atmosphere[3]

The original FMP specifically provided the background information required by the regulation regarding the Benicia Refinery, the Flare Gas Recovery System, and the associated flares. Specifically, the FMP includes measures that the Benicia Refinery has implemented to minimize flaring, historical rates of flare gas recovery and flaring events, flaring that may continue to occur for safety and environmental reasons, and the refinery's ongoing flare minimization procedures. It is worth noting and emphasizing that over the past 40 years the Benicia Refinery has made continuous improvement with respect to flare minimization with dramatic improvement in recent years.

Additionally, Regulation 12-12-404.1 requires that no more than 12 months following approval of the original FMP and annually thereafter, the owner or operator of a flare subject to this rule shall review the FMP and revise the plan to incorporate any new prevention measures identified as a result of the analyses prescribed in Sections 12-12-401.4 and 12-12-406. The updates must be approved and signed by a Responsible Manager. This document is the annual update designed to meet the requirements of Regulation 12-12-404.1 and to that end, the changes to the FMP are primarily in Sections 1 and 3. To ensure consistency in future years, the FMP Updates are due no later than October 1 each year. The FMP Update due on October 1, 2009 addressed flaring activity during the 13-month period from June 1, 2008 through June 30, 2009. Annually thereafter, all FMP Updates will cover the 12-month period from July 1 through June 30 ("FMP Year").

At the Benicia Refinery, flare minimization procedures have been implemented through a combination of procedural approaches and equipment upgrades targeted at minimizing the flow of gases to the refinery's Flare Gas Header, and maximizing the recovery of gases from that system for reuse. Key aspects of this approach include the development of an effective maintenance program to reduce unplanned flaring, monitoring of flows in the Flare Gas Header, a program to identify the sources of base loads if they start to rise, and operational planning to minimize or eliminate flaring during planned or anticipated maintenance events. A final important component is the refinery's program to evaluate the cause of significant flaring events that do occur, with the lessons learned from the causal analysis incorporated as appropriate into refinery operations, planning, and/or maintenance procedures.

Using this causal analysis approach for over a decade has allowed the refinery to significantly minimize the frequency and magnitude of flaring events. Flare volume has been reduced by more than 50 percent post 2005 compared to pre 2005.This FMP and subsequent updates will become an integral component of the Benicia Refinery's continuing program to sustain and improve upon the exceptional results already achieved.

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[3] Not subject to the Regulation 12-12-301 standard, but listed since the FMP addresses these types of flaring events.

of the Benicia Refinery FMP was submitted to USEPA (refinerynsps@epa.gov) on September 25, 2014.

In accordance with 40 CFR 60.103a(h), the flares shall not burn fuel gas with an H2S content in excess of 162 ppmv in a 3-hr rolling period. The combustion of process upset gases (resulting from a start-up, shutdown, upset, or malfunction), relief valve leakage, or other emergency malfunctions is exempt from this limit.

In accordance with 40 CFR 60.107a(h), the Benicia Refinery complies with Regulations 12-11 and 12-12 as an alternative to complying with 40 CFR 60.107a(e) and (f). Although not required by NSPS Ja, total sulfur CEMS were installed on the North and South flares in November 2015. These CEMS are used for SO2 emissions reporting required by Regulation 12-11-502.3.3 and replaced the automatic flare sampling Changing from 3-hour H2S flare gas sampling pre-2016 to continuous, online total sulfur analysis post-2016 should provide more accurate SO2 emissions

1.3 MACT CC Overview

On December 1, 2015, the USEPA promulgated the Petroleum Refinery Sector Rule (RSR). RSR included changes to the National Emission Standards for Hazardous Air Pollutants From Petroleum Refineries (MACT CC). The flare standards in MACT CC go into effect January 30, 2019.

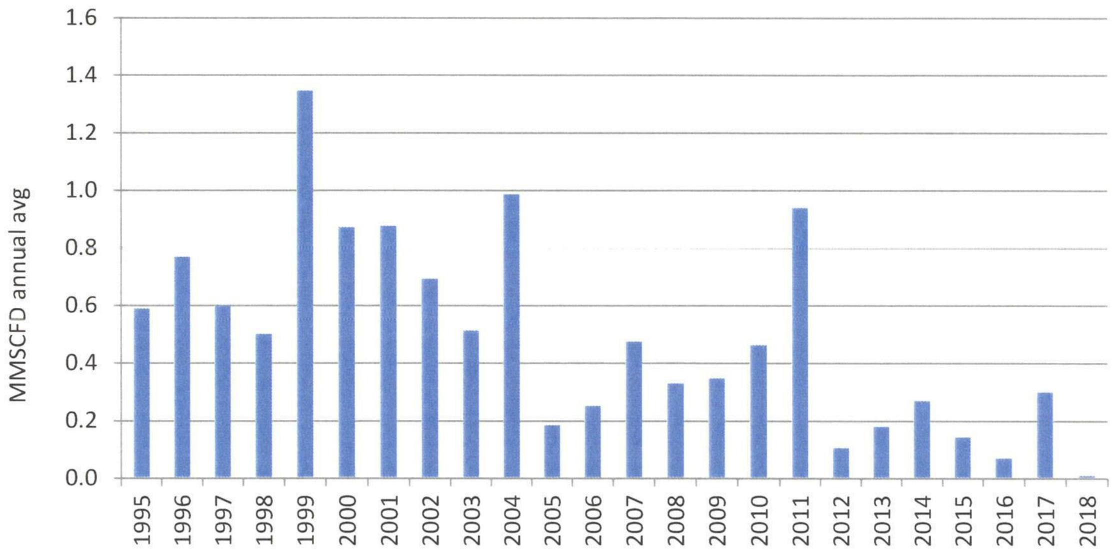
The North, South, and Acid Gas flares at the Benicia Refinery are subject to the flare standards in MACT CC. The Butane Flare is not subject to MACT CC because the material routed to the Butane Flare does not contain hazardous air pollutants (40 CFR 63.640(a)(2)).

The key flare standards in MACT CC include flare control requirements of 40 CFR 63.670, flare monitoring system requirements of 40 CFR 63.671, and the applicable reporting and recordkeeping requirements of 40 CFR 63.655. The MACT CC requirements are listed in 40 CFR 63.670(o)(1). This FMP incorporates the requirements for BAAQMD and will incorporate MACT CC FMP requirements by January 30, 2019.

For the North and South flares, the Benicia Refinery is installing supplemental natural gas lines in order to comply with the combustion zone operating limit of 270 BTU/scf in 40 CFR 63.670(e). The North and South flare existing gas chromatographs (GCs) will be used for the flare vent gas composition monitoring as outlined in 40 CFR 63.670(j)(1). These GCs will be modified to meet the requirements of 40 CFR 63.671(e) and Table 13.

For the Acid Gas flare, an application for exemption from vent gas composition monitoring was submitted to BAAQMD on January 30, 2017 in accordance with 40 CFR 63.670(j)(6).

Figure 1 – Flare Vent Gas Volume



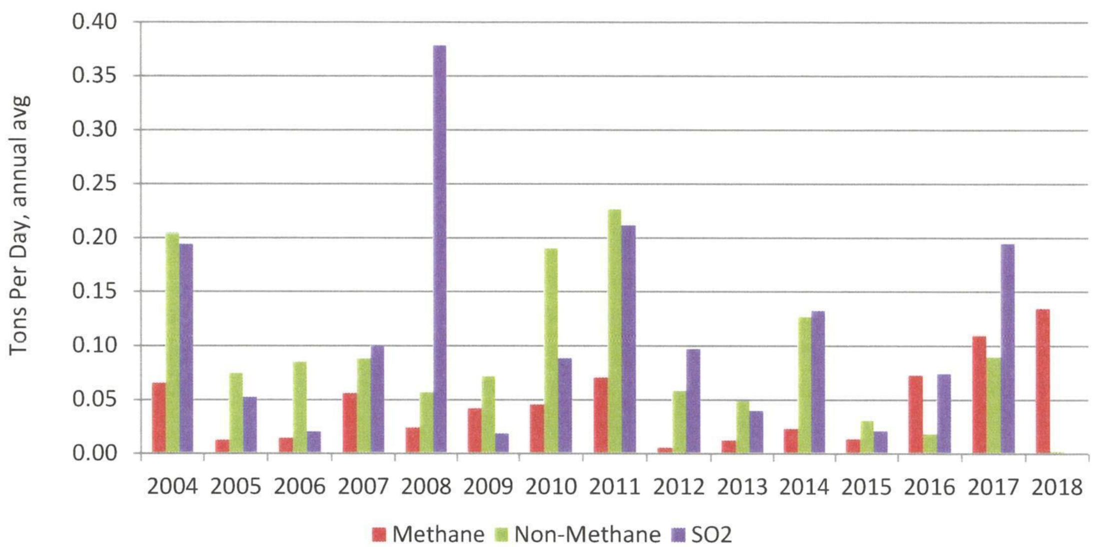
Note: The first half of 2018 displays a low MMSCFD average. The low average is due to a low turn around year and adjustments that were made to the NF and SF water seal drums to increase the water level.

In 2011 Valero had greater flare volume than recent historical flaring due to a refinery-wide turnaround that began at the end of 2010 and continued into 2011. During this event, all refinery units were shutdown, maintained and restarted. During the 2005-2010 period of relatively low flaring, 2007 had the greatest flaring due to a significant maintenance event (mid-cycle turnaround) in which a significant number of refinery units were shutdown, maintained, and restarted. 2012 through current have low flare flows because the equipment is at its generally optimal status following a refinery-wide turnaround. In 2017, there was slightly higher flaring volume due to a refinery-wide turnaround in the first half of the year followed by a total power outage to the refinery in May 2017. In 2018, there has been a significant reduction in flaring due to minimal turn around activities and adjustments made to the north flare and south flare water seal drums and the flare gas recovery compressors in order to increase the optimization of the flare recovery system. The changes have increased the amount of backpressure required to overcome the water seals and provides more opportunity for the flare gas recovery compressors to recover smaller volumes routed to the flare system.

For comparison purposes, these data are best considered in discrete periods of time, depending on whether maintenance (turnaround) occurred during the year:

- The higher volume years correspond with comparable refinery-wide turnaround years, such as 1999, 2004, 2011, and 2017.

Figure 2 – Flare Vent Emissions



Note: The first half of 2018 displays a low non-methane and SO2 average. The low average is due to a low turn around year and adjustments that were made to the NF and SF to increase the water level on the water seal drums.

1.4.3 Flaring Events

The correlation between flare volume and flare emissions is not exact because the composition of flare gas is not always consistent. In 2008, a higher than normal flare gas composition of hydrogen sulfide resulted in relatively higher sulfur dioxide emissions even though the flare gas volume was relatively low compared to other years. The relatively higher hydrogen sulfide vent gas composition and corresponding higher sulfur dioxide emissions in 2008 were caused by a single flaring event associated with the emergency shutdown of the Fluid Catalytic Cracking Unit (FCCU) and subsequent restart of the unit from February 28 through March 6, 2008. The emergency shutdown was required to repair a leak on the bottom pumparound line at the FCCU fractionator tower (T-701).

As a result of this flaring event, Valero implemented two important prevention measures to minimize the likelihood of a similar flaring event in the future. Valero implemented procedures to incorporate vent gas hydrogen sulfide sampling results into flare minimization strategies as the sample results become available. This allows Valero to make quicker decisions with respect to flare minimization based hydrogen sulfide composition in additional to vent gas volume data which is available in real time. Additionally, Valero modified both shutdown and startup procedures to improve the

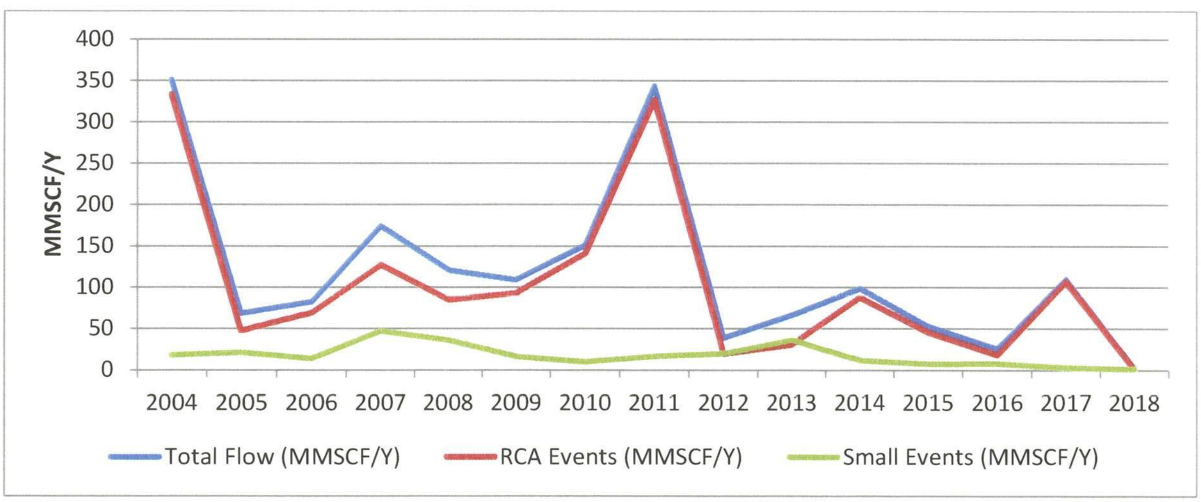
the flare gas recovery compressors to recover smaller volumes of gas routed to the flare system.

Each of these flare events was investigated and prevention measures were identified and implemented. The results from the investigations were reported to BAAQMD in Causal Analysis reports. All flaring, when it occurred, was minimized and stopped as soon as practical. We continue to investigate flaring events and implement prevention measures to minimize or prevent re-occurrence. However, one emergency flaring event can significantly affect the annual totals. Ultimately flares are essential refinery safety equipment. They provide a means to ensure the safe and efficient combustion of gases that would otherwise be released to the environment.

Every causal analysis investigation results in improved flare minimization awareness. The awareness is reflected in the existing equipment, existing procedures and extends into the evaluation of options for additional capital equipment and modifications to operating procedures to further reduce the volume of gas flared. Careful planning of any activity with the potential for flaring is the most successful minimization approach that has been implemented at the Benicia Refinery. Procedures for reporting and investigating all flaring provide a means to learn from unanticipated events.

Small flare events are those less than the RCA Events. Figure 3 below clearly shows that the small events (shown in green) are not where significant effort should be made to reduce flaring. Since 2004, small flare events only account for an average of 15% of the total flare vent gas vent volume, illustrating the effectiveness of Valero's flare minimization effort. The lessons learned from the RCA event investigations have been applied to the 'small event flaring' and the reader should refer to the prevention measures discussed in the FMP as a whole.

Figure 3 – Flare Vent Gas Volume – RCA Event vs. Small Event Comparison



The Benicia Refinery is a modern petroleum refining facility, with a maximum permitted crude throughput rate of approximately 165,000 barrels per day (BPD) making it a moderate sized refinery compared with typical US facilities. The refinery produces a range of refinery products including propane, butane, gasoline, jet fuel, diesel fuel and fuel oil. The Valero Benicia Asphalt Plant (BAP) also operates on the site producing different grades of paving asphalts.

Major processing systems in the refinery include atmospheric crude distillation and vacuum crude distillation at the Pipestill (PS), hydrocracking (HCU), fluid catalytic cracking and distillation (FCCU), cat feed hydrotreating (CFHT), fluid coking and fractionation (CKR), light ends distillation (VLE and CLE), naphtha and distillate hydrotreaters (VNHF, LCNHF, HCNHF, JHF and DHF), catalytic naphtha reforming unit (NRU), motor gasoline reformulation (MRU), alkylation (ALK), dimate (DIM), butamer (BTR), and fuels storage and blending or Oil Movements (OMS). The facility also operates a hydrogen production plant (H2U), electrical power and steam production plant (COGEN), a sulfur gas unit (SGU) and tail gas unit (TGU) for recovery of sulfur, a wastewater treatment plant (WWT), shipping and marketing terminals, and utilities (UTIL) that support operations of the refinery complex. The refinery configuration is typical for an upgrading or fuels producing facility. A simplified operations flow diagram is provided in Figure 4.

As of January 2011, the Refinery installed and began operating a flue gas scrubber unit (FGS). This extensive abatement system reduces emissions of sulfur dioxide (SO2), nitrogen oxides (NOX), sulfur trioxides (SO3), greenhouse gases (GHG), and particulates to levels previously unachievable with the former equipment. The FGS treats SO2 emissions from the CKR and the FCCU which were previously unabated and vented to the Main Stack. The FGS project also replaced two CO furnaces at the PS with more efficient CO furnaces and exhausts through a new dedicated stack.

One unique feature of the refinery is that it was designed with the processing units highly integrated with each other. This approach maximizes energy efficiency and minimizes the storage of intermediate products; however, it also results in the refinery as a whole functioning essentially as one integrated unit. When one of the major, central processing units such as the PS is taken out of service, the entire refinery generally is also taken out of service at the same time.

2.1.2 Refinery Fuel Gas Production

Refineries are designed and operated so that there will be a balance between the rates of fuel gas production and consumption. Under normal operations most gases produced by the refinery are routed directly to the refinery's fuel gas unit, allowing them to be used as a source of fuel in refinery furnaces, boilers, and other combustion devices. Typical refinery fuel gas units operate with a base loading of fuel gases generated in the refinery with additional natural gas supplied to the system as needed on pressure control to satisfy the refinery's total energy requirement. This provides a simple way to keep the system in balance, so long as the demand for fuel gas exceeds the amount of fuel gas produced (i.e., the so-called "fuel gas balance"). Some additional operational flexibility is typically maintained by having the ability to burn other fuels such as propane or butane, and to a limited extent having the capability to adjust the rate of fuel gas consumption at furnaces, boilers, and other combustion devices.

Flared gases can potentially be recovered for blending into the fuel gas unit if they are of proper quality for reuse - of light hydrocarbon content with sufficient fuel value, not primarily nitrogen or steam or other low Btu gases, and not excessively high in sulfur content. Reuse also depends on having sufficient treatment and consumption capacity available.

The Benicia Refinery maintains a single Fuel Gas Unit which must balance the demands of the fuel consumers within the refinery with the fuel gas produced by the refinery. The Fuel Gas Unit is also closely integrated with the refinery's hydrogen system, which like fuel gas is both produced and consumed within the refinery. Excess hydrogen can be returned to the Fuel Gas Unit within certain limits on quality and quantity.

The major users of refinery fuel gas include furnaces, boilers, four process gas turbines, and the COGEN plant. All of the users require the fuel gas to have a sufficient level of heating value (Btu content) to sustain proper combustion, particularly in burners that are specially designed to minimize the generation of NOX emission (e.g., low NOX burners). The sulfur content of the fuel gas must also be limited to minimize the formation of SO2 emissions when burned. Most of the refinery gases contain some amount of sulfur, so they are collected and treated to reduce sulfur levels (by amine absorption) with subsequent recovery of the sulfur at the SGU.

Different operations in the refinery produce fuel gases of different qualities. These are usually segregated to produce specific refinery products or intermediate streams. The atmospheric distillation (PS), NRU, and hydroprocessing units (CFHF, VNHF, LCNHF, HCNHF, DHF, JHF, ULSD and front end of HCU) produce gases that are primarily saturated hydrocarbon compounds which are separated into propane, butane, and gasoline range materials, and light ends which are routed to the Fuel Gas Unit. Heavy oil upgrading processes (primarily the CKR and FCCU) produce gases that contain significant amounts of unsaturated hydrocarbons (olefins) which are processed into fuel gas for internal use, chemical feedstocks (e.g., propylene and butylene), or are reacted further to produce gasoline range materials (e.g., dimate and alkylate).

routed to the central refinery flare gas recovery system. The KO drum and header system may serve one process unit, or may serve a number of units in one integrated system.

A typical central refinery flare gas recovery system consists of a series of branch lines from various unit collection systems which join a main flare gas header. The main flare gas header is in turn connected to one or more flare gas compressors and to one or more flares. Normally, all vapor flow to the flare gas header is recovered by a flare gas compressor(s), which routes the gases to a fuel gas treatment scrubber(s) were contaminants such as sulfur are removed. Process gasses that are generated in excess of what can be handled by flare gas compressor(s), treatment scrubbers(s) and/or fuel gas consumers flow to a refinery flare where they are safely disposed of by combustion.

A water seal drum is typically located at the base of each flare to serve several functions. A water level is maintained in the seal drum to create a barrier which separates or “seals” the flare gas header from the flare. The flare gases must pass through this water in order to get to the flare. The depth of liquid maintained in the seal determines the pressure that the gas in the flare gas header must reach before it can “break” the seal and enter the flare. This creates a positive barrier between the header and the flare, ensuring that so long as the flare gas recovery system can keep pace with net gas production, there will be no flow from the flare gas header to the flare. It also guarantees that a positive pressure will be maintained at all points along the flare gas header, eliminating the possibility of air leaking into the system which could create an explosive atmosphere. Finally, the seal drum provides a positive seal to isolate the flare, which is itself an ignition source, from the header and the process units. Some flare gas recovery systems combine multiple flares with a range of water seal depths, effectively “staging” operation of the various flares.

Gases exit the flare via a flare tip which is designed to promote proper combustion over a wide range of gas flow rates. Steam is often used to improve mixing between air and hydrocarbon vapors at the flare tip, improving the efficiency of combustion and reducing smoking. A properly designed flare tip will also help to minimize noise levels during flaring events.

A small amount of fuel gas or natural gas continuously flows to each flare for two reasons. First, the pilots on the flare tip are kept burning at all times to ignite any gas flowing to the flare. Additionally, for some flare systems, a small purge gas flow is required to prevent air from flowing back into the flare stack. Properly designed and operated flare systems destroy at least 98 percent of the hydrocarbon compounds that reach them, producing combustion products of CO2 and water. Other combustion products include sulfur oxides (SO2) if there are sulfur compounds in the flared gases and small quantities of nitrogen oxides (NOX).

The Benicia Refinery operates one main Flare Gas Recovery System with two flares (South and North) that fall under Regulation 12-12. The main refinery Flare Gas Recovery System collects sources from throughout the refinery and directs the gas to the Flare Gas Compressors. If there is excess flow, or if the gas quality makes it unsuitable for recovery, the gases flow to the two main refinery flares – the South Flare and North Flare. Flow of remains a preferred or required option. Some causes of flaring cannot be eliminated, despite careful planning and system design to minimize the risk of occurring. These flaring events can be summarized as falling under, but not limited to, one or more of the following broad categories:

- maintenance activities including process unit startup, shutdown, and turnaround events;
- fuel gas quantity and quality issues such as a fuel gas imbalance or out of range fuel gas heating value (Btu);
- equipment failure and malfunction including process upsets;
- loss of a major process unit compressor;
- equipment overpressure or other cause for relieving safety valves;
- leaking or malfunctioning safety valves;
- operator error;
- emergency conditions beyond the reasonable control of the Benicia Refinery or its operators caused by sudden, infrequent, and not reasonably preventable equipment failure, natural disaster, acts of war or terrorism, acts of God, external power curtailment, loss of utilities (e.g., power, cooling, steam, and instrument air), or fire; and
- safety – to prevent an accident, hazard, or release of vent gas directly to the atmosphere.

This above listing of broad categories of flaring events reflects the varied nature and many potential causes of flaring. The broad categories are intended to cover the range of conceivable flaring events that could potentially occur at the Benicia Refinery as required by Regulation 12-12-301. Further specific examples of types of flaring events associated with maintenance activities, fuel gas quantity and quality, and equipment failure and malfunction are provided below to assist in the understanding of the Flare Gas Recovery System and its critical role in refinery operations. This listing is not intended to be fully comprehensive of all specific potential relief events, but generally demonstrates the types of events that could occur.

There are also sources of normal or base level flow to the refinery flare gas recovery system that, at times, may result in small volumes of flaring. These volumes are usually very low and/or short in duration and do not cause a flaring event. Some examples of these small base load sources are: leaking safety valves awaiting maintenance, instrument purges, and pressure control for refinery process equipment. In addition to this low level base load, there are other sources of normal flows to the refinery flare gas recovery system (such as routine maintenance operations or process functions). This listing is not intended to be fully comprehensive of all normal or base level flows to the refinery flare gas recovery system, but generally demonstrates the types of activities that could occur.

Catalyst change-outs, which may include the need to strip hot catalyst with hydrogen or nitrogen, cool hot catalyst beds, and free the vessels of hydrocarbons before opening. Some catalysts that are pyrophoric in nature require even further special processing to maintain them in an inert oxygen free environment.

Conditioning of replacement catalyst with sulfur compounds prior to startup which may generate more fuel gas and/or hydrogen than can be managed in the Fuel Gas Unit and/or more hydrogen sulfide than can be treated by the Fuel Gas Unit.

Startup procedures where high pressure vessels must be slowly heated prior to "pressuring up" the vessel to prevent metal failure events (e.g., brittle fracture), which result in directing hot inert gases to the Flare Gas Recovery System.

Startup sequencing procedures where processing units (e.g., FCCU) may need to be restarted before the downstream gas processing units (e.g., CLE) can be brought into service.

Planned or unplanned maintenance activities for the COGEN unit. This unit has been a critical component of the flare minimization program. However, it can require major maintenance approximately every six months. It is also subject to the periodic outages associated with all major equipment. During these outages, the normal fuel gas balance in the refinery is dramatically impacted, and measures must be taken by the refinery to bring the system back into gas balance.

As noted above, refinery maintenance activities can create the need to divert nitrogen and/or hydrogen rich gases that are produced during maintenance away from the Flare Gas Compressor to a flare. This is a necessary result of the maintenance procedures which have been adopted to minimize the release of hydrocarbons to the atmosphere during equipment opening, and is in fact desirable, as any hydrocarbons in the gases are effectively combusted in the flare system. It should be noted that both nitrogen and hydrogen do not produce undesirable compounds upon combustion (excluding a very low potential quantity of NOX compounds). Some maintenance activities can also utilize steam, which can also impact the Flare Gas Recovery System. The need to divert gas to the flare is generally driven by the quantity and composition of the gases produced during maintenance, including startup, shutdown, and turnaround.

Fuel gas composition can have a significant impact on the equipment in the Flare Gas Recovery System, at the downstream Fuel Gas Unit and at the fuel gas consumers. A summary of these potential impacts are provided below:

High nitrogen or hydrogen content can impact furnaces, boilers, gas turbines, and COGEN by producing a low Btu gas that potentially could cause flameout and/or instable operation.

High nitrogen or hydrogen content can impact the capacity of flare gas compressors if they are designed for a significantly different molecular weight.

2.2.1.2 Hydrogen and/or Low Molecular Weight Gases

There is also the potential for much lower than average molecular weight recovered gas if increased flows of hydrogen occur. There are many process and reactor systems within the refinery that contain gases with high hydrogen content. When this equipment is decommissioned by depressurization to the flare gas header, there can be a sharp decrease in the flare gas' average molecular weight. Compressors are limited in their ability to function at significantly lower-than-design molecular weights, and mechanical damage, overheating or other malfunctions can occur. Hydrogen is also used for some catalyst cleaning, or "hot stripping" processes to remove residual hydrocarbons.

2.2.1.3 High Steam Content

A major advantage of using steam to clear hydrocarbons from equipment is its elevated temperature. However, this can be a disadvantage with respect to flare gas recovery. When the distance the gas must travel to reach the flare gas compressor is large (the Flare Gas Header is long), the gas will cool, and much of the steam will condense and be removed as water at the knock-out drum. However; with a shorter flare line or a long-duration steam out event, the temperature of the flare gas at the flare gas compressor can be elevated significantly. If the temperature of the flare gas stream at the inlet to the flare gas compressor exceeds machine limits, the gas must be diverted away from the compressor inlet in order to avoid mechanical damage. High temperature limits can also be exceeded within the stages of the compressor if the feed gas temperature is too high.

Another disadvantage of the use of steam is that most of what is added as a vapor will condense in the flare gas headers and must be removed via the water boot of a knock-out drum, either as the result of cooling as it flows through a long flare line or in a chiller/condenser included specifically for removal of water vapor from the flare gas. Either way a sour water stream is produced which will require treatment.

2.2.2 Fuel Gas Quantity and Quality

In general, flaring can occur as a result of fuel gas quantity and quality issues if (1) the quantity of fuel gas generated is larger than can be managed by the Flare Gas Compressors, Fuel Gas Unit, and/or fuel gas consumers; or (2) the quality (composition) of fuel gas is such that it must be routed to the flare because it cannot be utilized by the fuel gas consumers for a variety of reasons which may include safety, stringent gas turbine specifications, and to ensure low NO_X performance. When flaring is caused by fuel gas quantity and quality issues, the general cause is often maintenance activities, equipment failure and malfunction, emergency situations, and/or safety reasons. The quality and quantity of the fuel gas will also vary depending on the type of crude oil being processed, the severity of operations, and the relative contributions from the various process units. As discussed above, there is always a base-load to the Flare Gas Header. Therefore, flaring can also occur as a direct result of fuel gas quantity and quality issues

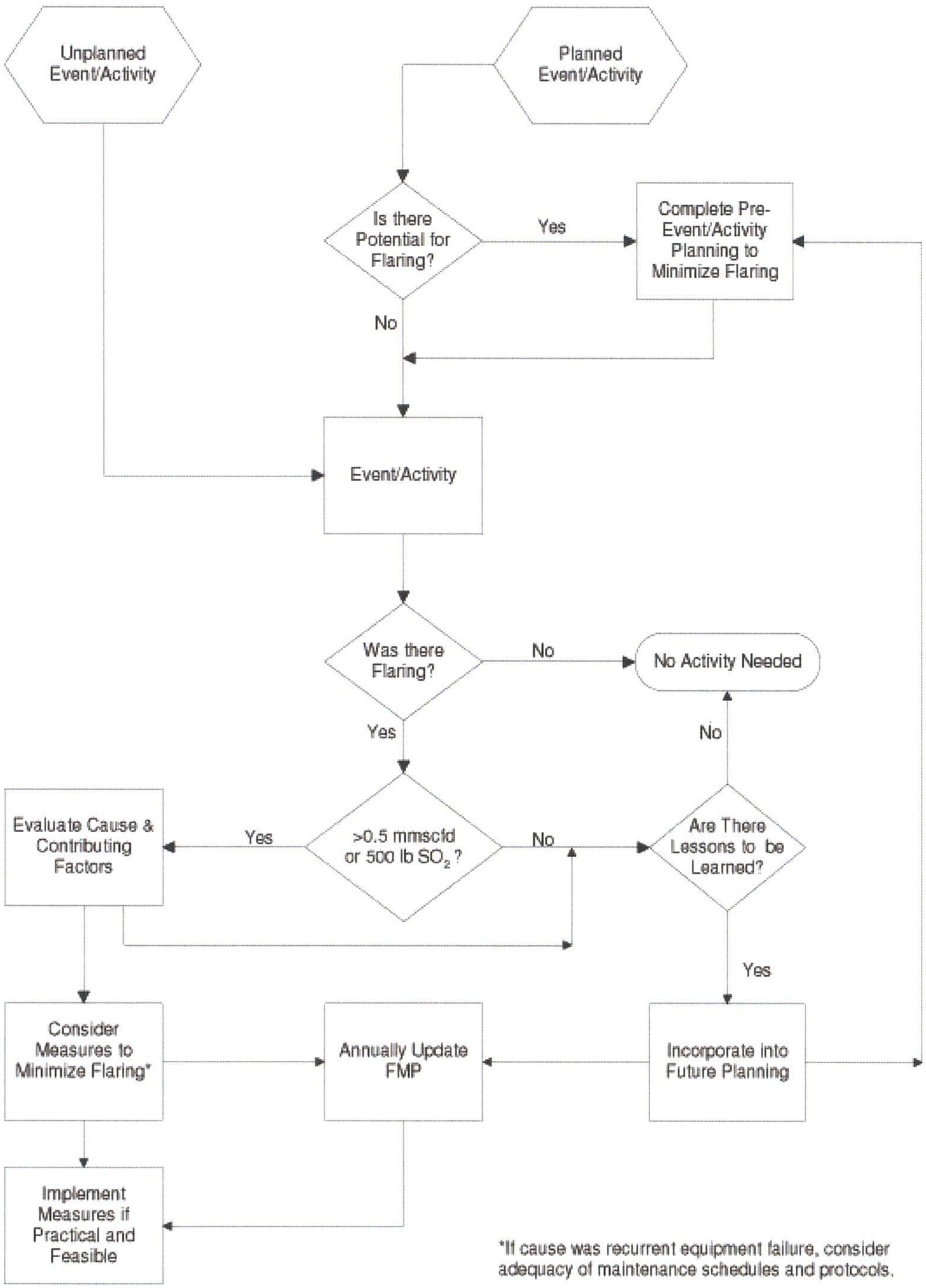
- Flaring can be caused by failure or malfunction of major and/or minor equipment such as compressors, cooling systems, electrical switching equipment, pumps, valves, and instrumentation. Rotating equipment in the difficult services that exist in a refinery will always have a finite service factor, even when maintained at or better than industry standard levels of reliability. Even with an effective preventative maintenance program in place, equipment failures will at times still occur.
- Equipment failure and malfunction, including process upsets, can result in the need to quickly depressure vessels and other process equipment to the Flare Gas Header. This often results in a situation where the capacity of the Flare Gas Compressors and/or the Fuel Gas Unit is not sufficient to process all of the gas that is generated. As a result, the flares may be used to safely combust excess gases.
- Flaring can be caused by a complete or partial loss of a major utility such as cooling water, electrical power, steam production, and instrument air. These types of events can significantly impact refinery gas condensing capability which is likely to result in the generation of more gas than can be managed by the Flare Gas Compressors and/or Fuel Gas Unit.
- Malfunction or loss of a compressor (or ancillary equipment item) used to process refinery gases (Cat Gas Compressor, Coker Gas Compressor). Reduced capacity or loss of this equipment can result in significant flow of gases to the Flare Gas Recovery System until the plant is returned to its normal mode of operation and/or the equipment can be repaired.
- Malfunction or loss of an online Flare Gas Compressor can have a significant impact on the ability to recover fuel gas. Because of the difficult service for these compressors, the off-line compressor must typically be maintained or repaired before it is available as a spare compressor. As a result, even though the Benicia Refinery has a backup Flare Gas Compressor, it is possible that both compressors could be offline at the same time. For example, if the reliability and required maintenance of the compressors is such that they have each have 95 percent online availability, statistically they would both be offline 0.25 percent of the time or about one day per year.
- Process or equipment failure or malfunction of the fuel gas treatment scrubbers, the amine regenerator, SGU, TGU, and/or associated equipment.

For the refinery emergency situations listed above, it is critical that the refinery flare systems are available to safely dispose of large quantities of gases that may be generated. The flares prevent these gases from being released directly to the atmosphere and significantly reduce any potential safety and environmental impacts.

2.3 Current Flare Minimization Procedures

The Benicia Refinery has a long history of implementing physical and procedural changes to improve the effectiveness of the Flare Gas Recovery System. While reductions in flared gas volumes have been achieved in recent years (as discussed in Section 3), the Benicia

Figure 5 – Flare Minimization Flowchart



*If cause was recurrent equipment failure, consider adequacy of maintenance schedules and protocols.

July 26, 2006

- Will the gases that are generated during depressuring, venting, purging, or other activities be of a quality that is acceptable for recovery?
- What mitigating activities should be incorporated in the activity plan to manage the potential flows to the Flare Gas Recovery System and/or the associated flares?
- Any recommendations that are identified during this planning process are then considered for inclusion in the activity procedures and incorporated as appropriate.

2.3.2 Flaring Event Review Program

An important component of the flare minimization process is the review of flaring events that occur and exceed the BAAQMD levels for reportable flows (greater than 0.5 mmscfd or 500 lb/day SO_2 emitted). The flaring event review process is incorporated with the BAAQMD reporting requirements in the following manner:

The occurrence of a reportable flaring event is identified;

- The event is managed to ensure the safety of facility operations, with the operations team considering both the maximization of the recovery of gases from the Flare Gas Header (depending on composition), and the minimization of any flared gases;
- All recordkeeping required by BAAQMD regulations is accomplished including flow recording, sampling of flared gases, and monitoring of flare drum seal levels;
- These results are compiled to prepare a summary of the event quantities and flows; and
- An analysis is performed to identify the cause of the event.

The causal analysis involves a coordinated team of refinery operations, environmental, and staff from other disciplines as appropriate (e.g., mechanical and electrical). The team reviews the operational conditions and activities leading up to the flaring event, and upon determining a cause, identifies any potential follow-up activities that may be implemented to minimize or eliminate the possibility of a similar event occurring. However, in some cases, the cause of flaring cannot be determined. Typically, this is because the event is minor (<0.5 mmscf and/or 500 lbs SO2). The Valero Benicia Refinery has developed systems to try and pinpoint the cause of all flaring events, most of which can be traced back to a source, but there are instances when a direct cause cannot be determined.

Typical recommendations may include improvements to maintenance procedures, changes to operational practices, the addition of instrumentation to monitor critical parameters, and/or changes to the planning and execution of similar activities in the future to minimize the chance of a similar event.

2.3.3 Flare Minimization Through Reliability Improvement

Over the years, the Benicia Refinery has instituted a series of management practices that have a direct and positive impact on the reliability of the equipment and processes in the refinery. These practices address such issues as equipment mechanical integrity, maintenance and inspection, training, and operating procedures. They generally can be

2.4 Refinery Flare Gas Recovery System including South and North Flares

The sources of normal or base level flow to a refinery flare gas collection system are varied, but in general result from many small sources such as leaking relief valves, instrument purges and pressure control valves for refinery equipment items (e.g., overhead systems for distillation columns). Added to this low level base load are small flow spikes from routine maintenance operations, such as clearing hydrocarbon from a pump or filter by purging the volatiles to the flare gas header with nitrogen or steam. Additional flare load can also result from routine process functions often related to operation of batch or semi-batch equipment, for example, the regeneration procedures performed at catalytic naphtha reforming units which involve periodically removing hydrocarbon residuals from catalyst beds via a variety of procedures and directing the resulting gases to the recovery header.

Also, scheduled maintenance activities often result in higher flows to the flare gas recovery system. Equipment being prepared for maintenance must be essentially free of hydrocarbons before opening. This is necessary for both safety and regulatory reasons, including compliance with Regulation 8-10. Typical decommissioning procedures include multiple steps of depressurization and purging with nitrogen or steam, neither of which is suitable for recovery as fuel gas, to the flare gas header.

Although maintenance-related flows can be at times large, the ultimate design and sizing of refinery flare systems is, without exception, driven by the need for the safe disposal of much larger quantities of gases during emergencies and process upsets. A major emergency event, such as a refinery power failure, requires the safe disposal of a very large quantity of gases during a very short period of time in order to prevent a large increase in system pressure and avert a serious accident, hazard, or release of refinery gas directly to the atmosphere. The flows that the flare system manages during an event of this type are several orders of magnitude greater than the normal or baseline flow rate.

A header for collection of vapor streams is included as an essential element of nearly every refinery process unit. These headers are commonly referred to as flare gas headers because they are typically connected to a flare system. However, at many refineries, including the Benicia Refinery, most of the gases sent to a flare gas header are normally routed away from the flare(s) and recovered using a flare gas compressor(s) to send the gases to a fuel gas unit where they become fuel for the refinery's furnaces, boilers, and other combustion devices. At most refineries, the quantity of gas in the flare header needing recovery is relatively small in comparison to the total quantity of fuel gas produced at the refinery. However, it is in the economic interest of the refinery to recover even this small fraction of gas instead of sending it to a flare, because these recovered gases offset the need to purchase additional fuels such as natural gas.

The primary function of the flare gas header is safety. It provides the processing units with a controlled outlet for any excess vapor flow, nearly all of which is flammable, making it an essential safety feature of every refinery. Each flare gas header also has connections for equipment depressurization and purging for maintenance activities including startup, shutdown and turnaround. PRDs are also routed to the header system to handle process flare. Additionally, for some flare systems, a small purge gas flow is required to prevent air from flowing back into the flare stack.

Properly designed and operated flare systems destroy at least 98 percent of the hydrocarbon compounds that reach them, producing combustion products of CO_2 and water. Other combustion products include sulfur oxides (SO_2) if there are sulfur compounds in the flared gases and small quantities of nitrogen oxides (NO_X).

At the Benicia Refinery, the Flare Gas Recovery System is used to recover excess gases that are generated at various refinery processing units. These gases are collected in the Flare Gas Header and a majority (approximately 90 percent) are compressed and directed to the refinery Fuel Gas Unit. At the Fuel Gas Unit, the recovered gases are blended with other refinery sources of fuel gas, treated for removal of sulfur compounds, and directed to the refinery fuel gas users, including furnaces, boilers, gas turbines, and COGEN. The system can also direct gases to one or both of the flares that are connected to the Flare Gas Header. However, this occurs only if the composition of the gases is not compatible for reuse as fuel gas (e.g., nitrogen, steam, or low Btu content), or if the instantaneous rate of flow exceeds the capacity of the Flare Gas Compressors. By recovering these gases and reusing them, the refinery achieves multiple objectives – increased energy efficiency, reduced oil loss, minimization of the frequency and magnitude of flaring events, and effective control of hydrocarbon emissions.

The major components of the Flare Gas Recovery System include process unit liquid knock-out (KO) drums, the Flare Gas Header, Flare Gas Compressors, the Fuel Gas Unit (including fuel gas scrubbers and distribution headers), flare water seal drums, and the two flares (South and North). Figure 6 provides a simplified diagram of the Flare Gas Recovery System at the Benicia Refinery. A detailed process flow diagram of the Flare Gas Recovery System (Drawing No. 36-000-03E-73503) is provided in Appendix B.

- D-2102 is located at the H2U and serves the H2U, HCU and COGEN units.
- D-2113 is located at the H2U and serves the CFHU, FG, DIM, SGU, COGEN and H2U units.
- D-2103 and D-2104 are located at the ALKY and serve the ALKY and UTIL units.
- D-2131 is located at ALKY and serves the ALKY and BTR units.
- D-2130 is located at the MRU and serves the MRU, ULSD, and BAP units.

There are additional tie-ins to the Flare Gas Header that are not routed through a process unit liquid KO drum. These tie-ins include various vapor recovery systems, product spheres, and the Acid Gas Flare system (via D-2107, the SGU Liquid KO Drum) which is normally closed.

The Flare Gas Header is a 42-inch line that runs throughout the refinery. This header is used to connect the process unit KO drums to two Flare Gas Compressors. A flare seal drum and a flare are also connected to both the south and north ends of the Flare Gas Header. One or two compressors are used to recover gases from the Flare Gas Header and send them to the Fuel Gas Unit where they are treated to produce fuel gas for furnaces, boilers, gas turbines, and COGEN. Under normal operating conditions, the Flare Gas Compressors remove enough gases in the Flare Gas Header to maintain a header pressure that does not "break" the water seal in the flare water seal drums. Under normal operating conditions, the south and north water seals prevent gases from reaching the flares and ensure that all the gases in the Flare Gas Header are compressed and sent to the refinery's Fuel Gas Unit.

Detailed piping and instrumentation diagrams of the process unit liquid KO drums (Drawing Numbers 112-KE-31, 114-KE-9, 116-KE-12, 43-000-03D-17468 and 44-000-03D-30869) are provided in Appendix C.

2.4.2 Flare Gas Compressors, C-2101 A/B

The Flare Gas Recovery System utilizes two Flare Gas Compressors (C-2101 A/B) to route gases in the Flare Gas Header to the Fuel Gas Unit via the Sour Gas Header. C-2101 A is a 3-stage compressor that was installed in 1975 (this unit was originally constructed in 1953 and was installed as a used unit). C-2101 B is a 2-stage compressor that was installed as a new unit in 1983. These two reciprocating compressors are each rated at 6 mmscfd. This rating is based on inlet conditions of 0 psig and 80F for C-2101 A and 0 psig and 70F for C-2101 B. Both of the Flare Gas Compressors discharge to the Sour Gas Header at 87 psig at 100F. When C-2101 A was originally installed it was designed to discharge to either the Sour Gas Header or to the higher pressure CLE, however, the line-up to CLE is not currently used.

Prior to 1975, all gases sent to the Flare Gas Header were flared, which was a common operating practice (and still is at many refineries throughout the world). The first Flare Gas Compressor (C-2101 A) was installed in 1975 when it was very uncommon for refineries to operate flare recovery systems. The Benicia Refinery operated for eight

Major maintenance of the Flare Gas Compressors is not scheduled and there are no manufacturer's recommendations for major maintenance. Flare Gas Compressor operating parameters are closely tracked. If there are indications that performance is beginning to degrade (e.g., increase in operating temperature or a decrease in compression capacity), the spare Flare Gas Compressor is first placed on-line as the new primary unit. After the spare Flare Gas Compressor is placed on-line, the original unit is taken off-line to conduct maintenance and repair. Once the maintenance and repair activities have been completed, that unit becomes available as the spare unit and is placed in hot standby. Minor maintenance activities such as lubrication are conducted at regular intervals.

Additionally, the Benicia Refinery has recently implemented a program of conducting an approximate 14-day major and an approximate 5-day minor inspection of each compressor approximately every 8 and 3 years, respectively. However, the inspection schedule is adjusted if major maintenance occurs based on tracking compressor performance (described above). At the time of the major and minor inspections, maintenance and repair is conducted based on the results of the inspection and can add to the time that the unit is down (not available as a standby unit).

There are no logic controls that would automatically trigger the spare Flare Gas Compressor to come on-line if the primary unit were to fail and go off-line. The spare compressor must be manually started. However, during a planned switch of the primary and spare compressor, the spare is always placed into service prior to removing the primary from service. In the event that the primary Flare Gas Compressor experiences a mechanical failure and goes off-line unexpectedly, the spare unit is started as soon as possible to minimize flaring. It typically takes approximately 10 to 20 minutes for an operator to be called out and complete the start-up sequence. During the period of time that there are no Flare Gas Compressors in service, all gases collected in the Flare Gas Header must be flared because there is no path to the Fuel Gas Unit.

The Flare Gas Compressors are equipped with a number of automatic shutdown controls to prevent mechanical failure. For example, both Flare Gas Compressors have a high temperature trip that is set at the maximum operating discharge temperature of 325° F. The Flare Gas Compressors are also equipped with automatic shutdown controls for high oxygen (set at 4 percent oxygen) to prevent a combustible mixture at the downstream Fuel Gas Unit. A number of issues can lead to high operating temperatures such as a problem with the lubrication and cooling systems. Higher than normal operating temperatures can also be a sign of excessive wear or other mechanical problem that require maintenance. If low molecular weight gases, such as hydrogen, are sent to the Flare Gas Compressors, operating temperature can potentially increase up to the high temperature trip point. High oxygen levels can be caused by air leaks into the Flare Gas Header. Flare Gas Compressor trip points are summarized in. It is extremely uncommon that the Flare Gas Compressors shutdown because of high temperature, high oxygen, or some other automatic trip. During a trip event, all gases sent to the Flare Gas Header would be sent to the South and North Flares. After a trip event, the spare Flare Gas

2.4.3 Fuel Gas Unit

The Flare Gas Compressors are used to send an average of about 4 to 5 mmscfd of gas from the Flare Gas Header to the Fuel Gas Unit. In the Fuel Gas Unit, these recovered gases are blended with other refinery gases and, at times, purchased natural gas to produce an average of about 75 mmscfd of fuel gas that is burned in refinery furnaces, boilers, gas turbines, and COGEN. In addition, the Fuel Gas Unit produces an average of about 23 mmscfd of hydrogen rich gases that are sent to the H2U. The following gas streams are produced at the Fuel Gas Unit:

- Low pressure fuel gas (LPFG) for furnaces and boilers;
- High pressure fuel gas (HPFG) for four process gas turbines located at ALKY, HCU, FCCU, and CLE;
- Pilot gas;
- A blend of refinery fuel gas and natural gas for the COGEN; and
- High pressure tail gas (HPTG) for the H2U.

The recovered gases (an average of about 4 to 5 mmscfd) are sent to the sour gas header and mixed with other gases which are sent to a Fuel Gas Treatment Scrubber (T-1201) to produce an average of about 50 mmscfd of clean refinery fuel gas. This scrubbed refinery fuel gas from T-1201 is then sent along with other gases and/or purchased natural gas to the LPFG system, HPFG system, and the COGEN fuel system. The scrubbed refinery fuel gas from T-1201 can also be sent to the pilot gas system which is normally supplied only with purchased natural gas. Figure 7 provides a simplified diagram of the Fuel Gas Unit.

The Benicia Refinery maintains a single Fuel Gas Unit which must balance the demands of the fuel consumers within the refinery with the fuel gas produced by the refinery. The Fuel Gas Unit is also closely integrated with the refinery's hydrogen system, which like fuel gas is both produced and consumed within the refinery. Excess hydrogen can be returned to the Fuel Gas Unit within certain limits on quality and quantity.

The major users of refinery fuel gas include furnaces, boilers, four process gas turbines, and the COGEN plant. All of the users require the fuel gas to have a sufficient level of heating value (Btu content) to sustain proper combustion, particularly in burners that are specially designed to minimize the generation of NOX emission (e.g., low NOX burners). The sulfur content of the fuel gas must also be limited to minimize the formation of SO2 emissions when burned. Most of the refinery gases contain some amount of sulfur, so they are collected and treated to reduce sulfur levels (by amine absorption) with subsequent recovery of the sulfur at the SGU.

Different operations in the refinery produce fuel gases of different qualities. These are usually segregated to produce specific refinery products or intermediate streams. The atmospheric distillation (PS), NRU, and hydroprocessing units (CFHF, VNHF, LCNHF, HCNHF, DHF, JHF, ULSD and front end of HCU) produce gases that are primarily ultimately recovered and sold as a product. The refinery operates additional fuel gas treaters which share a common amine regeneration system.

The Fuel Gas Treatment Scrubber (T-1201) has a maximum capacity of about 70 mmscfd of sour fuel gas. The clean fuel gas produced at T-1201 is regularly sent to the HPFG system, LPFG system, and COGEN fuel system. Additionally, the clean fuel gas can be sent to the pilot gas system. Light hydrocarbons (primarily methane and ethane) from CLE are the primary source of sour fuel gas that feeds T-1201. CLE supplies on average about 36 mmscfd of sour fuel gas to T-1201 which accounts for about 70 percent of the total sour fuel gas sent to T-1201. The gases at CLE are originally generated at the FCCU and CKR and are sent to CLE to produce pentanes and various intermediate feed products for ALKY, DIM, LCHFF, and HCNHF. The gases from CLE that are sent to T-1201 (about 36 mmscfd) account for a small percentage of the total gases processed at CLE.

There are a number of other smaller sour fuel gas streams that makeup the remainder of the sour fuel gas feed to T-1201 (the remaining 30 percent not supplied by CLE). The Flare Gas Compressors supply on average about 4 to 5 mmscfd of sour fuel gas to T-1201 which accounts for about 10 percent of the total sour fuel gas sent to T-1201. A majority of this remaining T-1201 feed comes from VLE which is primarily supplied by the PS and HCU.

A detailed piping and instrumentation diagram that includes the Fuel Gas Treatment Scrubber (Drawing No. 122-KE-2) is provided in Appendix C.

2.4.3.2 HPFG System

The HPFG system supplies an average of about 12 mmscfd of fuel gas at about 215 psig to the four gas turbines. HPFG is mostly comprised of refinery fuel gas that has been scrubbed in T-1201, which is then raised to a higher pressure by reciprocating compressors (C-2201 A/B, Stage 1). It is important that the heating value of HPFG is maintained between about 950 and 1100 Btu/scf because the gas turbines are sensitive to the heating value of fuel gas. On average, less than 1 mmscfd of purchased natural gas is blended into HPFG. Excess HPFG (compressed and scrubbed refinery fuel gas from T-1201 and C-2201 A/B, Stage 1) is sent to the LPFG system.

2.4.3.3 LPFG System

The LPFG system supplies an average of about 53 mmscfd of fuel gas at about 60 psig to the refinery. LPFG is used on a continuous basis at the furnaces and boilers throughout the refinery. In addition, LPFG is used for auxiliary startup burners at the FCCU and CKR and for a startup furnace at ALKY.

LPFG is primarily comprised of refinery fuel gas that is scrubbed at T-1201. LPFG also includes excess HPFG (compressed and scrubbed refinery fuel gas from T-1201 and C-2201 A/B, Stage 1) that is let down into the LPFG system. In addition, LPFG also includes excess hydrogen-rich tail gas from the HPTG system that is

A reciprocating compressor (C-2201 A/B, Stage 2) is used to compress the LPTG after scrubbing. The volume of HPTG sent to H2U reduces the amount of natural gas required to manufacture hydrogen.

When the supply of HPTG is greater than can be recycled to the H2U, a portion of the gas must be sent to the LPFG system. On average, about 8 mmscfd of scrubbed HPTG from T-1202 is let down into the LPFG system.

2.4.4 Flare Water Seal Drums, D-2105 and D-2112

The Flare Gas Recovery System at the Benicia Refinery utilizes two flare water seal drums, one located at the South Flare (D-2105) and one located at the North Flare (D-2112). The flare water seal drums serve two primary purposes; (1) to create a water seal for the Flare Gas Header which prevents gases from flowing to the flares during normal operating conditions and (2) to minimize the carryover of hydrocarbon liquid into the flares in the event that gases are sent to the flares. Liquids from the flare water seal drums are pumped to the sour water tank (TK-2801).

The South Flare water seal drum is equipped with 1-inch notched internal overflow weir to maintain a constant level for the water seal equal to the weir height. At the North Flare water seal drum, a constant water level is maintained using a 6-inch drain line that sends flow around an internal wall. The Flare Gas Header enters through the top of each flare water seal drum and extends into the water. The submerged end of the Flare Gas Header creates a positive barrier or "water seal" that prevents gases in the header from reaching the flare under normal operating conditions. To maintain a water seal, water is continuously supplied to the flare water seal drums. The water flow rate is controlled by restriction orifices. Stripped sour water is the primary water source with fire water used as a backup supply. The fire water backup is activated by a low pressure controller. Steam is also provided to D-2105 and D-2112 to keep the liquid warm.

Each flare water seal drum is equipped with a 24-inch diameter horizontal "H" sparger with approximately 8,000 ½-inch holes that allow for uniform distribution of gases beneath the water. Additionally, each flare water seal drum is equipped with an 8-inch diameter auxiliary sparger also with ½-inch holes. The auxiliary sparger in the North Flare water seal drum is normally closed. Table 2-2 provides the water seal heights for each flare water seal drum. If the pressure in the Flare Gas Header rises above normal operating conditions, the 28 inch water seal in the North Flarewater seal drum will be the first to "break" and gases will be sent to the North Flare. If the header pressure is great enough to break "H" sparger water seals, then gases will be sent to both the South and North Flares.

In 2018, adjustments were made to the north flare and south flare water seal drums and the flare gas recovery system. These changes have increased the amount of backpressure required to overcome the flare drum water seals and provides a greater opportunity for the flare gas recovery compressors to recover smaller volumes of gas routed to the flare system.

calculated using industry standard to obtain 6-8% oxygen or less within 25 feet from the flare tip.

A project is currently being implemented to install permanent natural gas purges in the north and south flare seal drums in order to meet the requirements of 40 CFR 63.670€ by January 30, 2019 as well as for purge gas. The natural gas line installation project will ensure that above the liquid level all space downstream of the liquid seal is purged. For the south flare, until the permanent natural gas purge can be installed, the oxygen concentration is monitored. If above 4% O2 the DCS alarms and a nitrogen purge is turned on to reduce the oxygen concentration.

Detailed piping and instrumentation diagrams that include the South and North Flares (Drawing Nos. 136-KE-7 and 136-KE-8 for the South and North Flares, respectively) are provided in Appendix C. A detailed process and instrumentation diagram that includes the flare pilot igniter for the South Flare (Drawing No. 136-KD-7C) is provided in Appendix C. The flare pilot igniter for the North Flare is shown on the North Flare piping and instrumentation diagram listed above (Drawing No. 136-KE-8).

2.5 Acid Gas Flare System

The Benicia Refinery operates an Acid Gas Flare which was installed in 1969 when the refinery was constructed. The Acid Gas Flare is designed to ensure effective destruction of primarily hydrogen sulfide and ammonia in relief vents that come from potentially sulfur containing streams located in the SGU. These vent streams from the SGU contain little or no hydrocarbons. These gas sources are not continuous and only rarely require venting. Since the implementation of Reg.12-11 there have been two reportable event greater than 500 lbs SO2, one on May 5-7, 2017 and one on December 8th, 2011. The most recent event occurred on May 5-7, 2017 and was due to a total and complete PG&E power outage. Prior to this event the last reportable event greater than 500 lbs SO2 occurred December 8, 2011, The May 2017 total and complete PG&E outage event has been the only reportable event greater than 0.5 mmscfd since flare monitoring was implemented under Regulation 12-11. The Acid Gas Flare presents two advantages by segregating higher sulfur gases from other recovered fuel gases – first, the higher sulfur sources can cause significant corrosion and require special materials of construction, and second, by segregating these sources any events that occur with high sulfur streams can be immediately recognized and addressed.

The major components of the Acid Gas Flare system include the SGU liquid KO drum, acid gas flare line, Acid Gas Flare water seal drum, liquid accumulator drum, and Acid Gas Flare. The Acid Gas Flare system does not use a compressor to recover acid gas because the flows are infrequent, of a low volume, and of high sulfur content that is not a good candidate for reuse as fuel gas. A detailed process flow diagram of the Acid Gas Flare (Drawing No. 36-000-03E-73504) is provided in Appendix B.

2.5.3 Acid Gas Flare

The Acid Gas Flare tip is located adjacent to the South Flare tip on the South Flare stack. A 16-inch diameter line connects the water seal drum to the Acid Gas Flare. Gases are burned at the flare tips which are a smokeless, steam-assisted design by John Zink. The design capacity of the Acid Gas Flare is 79,000 lb/hr including both purge gas and combustion assist gas. Steam is utilized at the Acid Gas Flare tip to minimize flare pluming. During flaring events, the steam rate is automatically adjusted to maintain a specific acid gas to steam ratio. Video monitors in the Refinery Control Center allow operators to observe flame characteristics.

The Acid Gas Flare is equipped with three pilots that burn constantly to ignite any sudden releases of gases to the flares. A constant supply of about 0.35 MMBtu/hr of pilot gas (refinery fuel gas and/or natural gas) is maintained at the flare. Temperature sensors at each pilot check for continuous operations. If there is a pilot failure, a trouble alarm is sounded at the Refinery Control Center and the pilots are ignited from the ground by a flame propagation system.

Combustion assist gas (fuel gas or natural gas) is typically added to the acid gas (at the acid gas water seal drum) at a rate of up to about 3.1 mmscfd to improve flare combustion during a flaring event. The addition of combustion assist gas is controlled by computer program to add fuel gas when a release is detected, either by the flow meter or if indicated by the valve position of sources routed to the flare. Additionally, the Acid Gas Flare utilizes a continuous flow purge gas from the pilot gas system (which is normally natural gas) to mitigate pulsation in the flare. A constant supply of about 0.05 mmscfd of purge gas is added to the 16-inch diameter line that connects the water seal drum (D-2106) to the Acid Gas Flare.

A detailed piping and instrumentation diagram that includes the Acid Gas Flare (Drawing No. 136-KE-7) is provided in Appendix C. A detailed piping and instrumentation diagram that includes the flare pilot igniter for the Acid Gas Flare (Drawing No. 136-KD-7C) is provided in Appendix C.

2.6 Monitoring Equipment

The Benicia Refinery operates flare monitoring and control equipment to ensure proper operation of the flare systems. This section provides detailed information regarding the various monitoring and control equipment.

2.6.1 Flare Volumetric Flow Rate Monitoring

In accordance with Regulation 12-11-501, the Benicia Refinery installed Panametrics ultrasonic volumetric flow meters in November 2003 at the South, North, and Acid Gas Flares. The meters were replaced for MACT CC compliance in May and July of 2018 in preparation for the January 30, 2019 compliance date. The new meters are FS100 SICK

The raw flow data for the Acid Gas Flare is "verified" by determining if the water seal was broken. If D-2106 differential pressure (dP) is less than the water seal head pressure, then the water seal is intact and there is no flow to the flare. Conversely, if D-2106 dP is greater than the water seal head pressure, then the water seal is broken and there is flow to the flare. The data historian tag number for D-2106 is UBP069 and the water seal is CVUBL013.

Detailed piping and instrumentation diagrams of the ultrasonic flow meters (Drawing Nos. 131-KE-19D, 131-KE-19E, and 131-KE-21B) are provided in Appendix C.

2.6.2 Pilot and Purge Gas Flowrate

In accordance with Regulation 12-11-504, the volumetric flow rate of pilot and purge gases must be (1) continuously monitored or (2) other information must be monitored so that it may be used to calculate the flow rate. The volumetric flow rate of pilot gas sent to the South, North, and Acid Gas Flares can be calculated based on continuous pressure monitoring and design information for nozzle size at the flare tip.

The North Flare purge gas (natural gas) volumetric flow rate is based on a restriction orifice diameter size. The South Flare purge gas (nitrogen) flowrate is based on a union orifice diameter size. For the Acid Gas Flare, a local flowmeter, 21F251, provides flow indication of the purge gas (natural gas). The volumetric flow rate of supplemental gas (refinery fuel gas) to the Acid Gas Flare is continuously monitored and recorded with flow meter 21F034. Pilot Monitoring

In accordance with Regulation 12-11-503, the South, North, and Acid Gas Flares are each equipped with a continuous burning pilot. The presence of a flame is continuously monitored with temperature monitors including 21T059 through 21T064 at the South Flare, 21T055 through 21T058 at the North Flare, and 21T065 through 21T068 at the Acid Gas Flare.

2.6.3 Flare Video Monitoring

The South, North, and Acid Gas Flares are video monitored in accordance with Regulation 12-11-A real-time digital image of each flare and flame are maintained with a frame rate of at least 4 frames per minute. The recorded image of the flare and flame are of sufficient size, contrast, and resolution to be readily apparent in the overall image. The image includes an embedded date and time stamp.

2.6.4 Flare Seal Drum Monitoring

In accordance with Regulation 12-12-501, water seal integrity monitors were installed prior to August 1, 2006 at the seal drums for the South, North and Acid Gas Flares (D-2105, D-2112, and D-2106). For each water seal drum, these instruments continuously monitor the water level and the water seal (pressure differential between the flare header and seal drum). Tables 2-3 and 2-4 provide specifications for the flare seal drum monitors.

Table 2-4 – Water Seal Monitors

Flare & Seal Drum	Level Monitor	Range (inches of water)
South Flare, D-2105	21P070	0 to 50
North Flare, D-2112	21P071	0 to 50
Acid Gas Flare, D-2106	21P069	0 to 10

(1)Pressure differential between the flare header and the seal drum.

2.6.5 Flare Gas Composition Monitoring

In accordance with Regulation 12-11-502, the Benicia Refinery monitors the composition of any gases that result in a reportable flaring event and provides compositional information to the BAAQMD when reports are submitted. Flaring events are defined as continuous events sensed by the SICK flare flow meters in excess of 330 scfm (0.475 mmscfd) for 15 continuous minutes or longer. Regulation 12-11-502.3.1.a requires that a sample be taken within 15 minutes of the start of a flaring event, and at three hour intervals during a flaring event.

In November 2015, the Benicia Refinery installed Siemens Maxum II Process GCs downstream of the North and South flare water seal drums for measurement of 0-300 ppm H2S pursuant to 40 CFR 60.107a(a)(2). Starting in 2016 these GCs also measure BTU components in accordance with BAAQMD Rule 12-11-502.3.4 and replace the automatic flare sampling used pre-2016.

BAAQMD Rule 12-11-601.3 requires GC analysis to meet ASTM Method D1945-96 or any alternative method if approved by the APCO and EPA. The Siemens Maxum II Process GC is applied in all sectors of the petrochemical industry and uses a molecular sieve and packed columns in two ovens. The left oven performs a backflush at 121°C and the right oven separates components at 80°C. This method is similar, but not exact, to the method described in ASTM D1945-96. The primary reason for the difference in methods is that ASTM D1945-96 is a lab method for analysis of natural gas whereas the Siemens analyzer uses methodology appropriate for process GC analyzer measurements and the components of flare gas.

In November 2015 the Benicia Refinery is also installed ThermoFisher Scientific SOLA II Flare Total Sulfur analyzers downstream of the North and South flare water seal drums, ranged from 0-5000 ppm and 0-50%. These analyzers are now used for SO2 emissions reporting required by Regulation 12-11-502.3.3 and replace the automatic flare sampling. Changing from 3-hour H2S flare gas sampling pre-2016 to continuous, online total sulfur analysis post-2016 may cause a step change in the SO2 emissions reported for similar flaring events.

Table 2-5 – Flare Analyzers

Flare	H2S/BTU Analyzer	Total Sulfur Analyzer
South	21A301/21A302	21A320
North	21A341/21A342	21A360

3. Flaring Reductions Previously Realized

In accordance with Regulation 12-12-401.2, this section of the FMP provides detailed descriptions of the equipment, processes, and procedures installed or implemented within the last five years to minimize the frequency and magnitude of flaring events at the Benicia Refinery. Because flare minimization activities started about 40 years ago at the Benicia Refinery, this section also includes some of the more important measures that have been implemented prior to the most recent five year period.

Table 3-1 provides an approximate chronological listing of flare minimization measures implemented at the Benicia Refinery for the South, North, and/or Acid Gas Flares. For each measure, the year of installation or implementation is provided if a precise date is known. Otherwise, a general time period is provided. Additionally, the effectiveness of these measures in minimizing the frequency and magnitude of flaring events at the Benicia Refinery is qualitatively shown as "significant," "moderate," or "minor."

Table 3-1 – Flaring Reductions Previously Realized

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
1975/76 to present	Equipment clearing procedures during shutdown prior to conducting maintenance activities are discussed in Section 4.1.1.	Significant
1975	Installed Fuel Gas Compressors (C-2201 A/B) and modified the Fuel Gas Unit to significantly reduce the refinery's use of purchased natural gas. As a result of this project, compression of low pressure fuel gas (LPFG) with the Stage 1 compressors is used to fuel the gas turbines. Additionally, the Stage 2 compressors are used for compression of low pressure tail gas (LPTG) which is used to feed the H2U. Prior to the installation of the Compressors, tail gas was let down to LPFG, which loaded up the LPFG system and caused flaring.	Significant
1975	Installed a Coker Gas Compressor (C-902) to reduce the volume of Coker Gas sent to the Cat Gas Compressor (C-701). This unloading of C-701 reduced the quantity of FCCU and Coker Gas sent to the Flare Gas Header and downstream flares (the Flare Gas Compressors had not yet been installed).	Significant
1976	Installed the first Flare Gas Compressor (C-2101 A) to provide recovery capacity of up to 6 mmscfd of flared gases. Prior to installation of this compressor, all gases sent to the Flare Gas Header were flared.	Significant

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
Late 80's	Installed a second electrical power feed from PG&E, the local utility provider. This second feed decreases the likelihood of power outages which typically result in significant flaring.	Significant
Late 80's to present	Revised the H_2 grid pressure control programs to stabilize low pressure H_2 grid pressure and reduce loss of H_2 to LPFG. The H_2 grid is separate from the Fuel Gas Unit, and supplies H_2 to the hydrofiners and the HCU. The H_2 grid has several cascading pressure levels whereby H_2 from one unit is re-used in another unit at a lower pressure level. The lowest pressure H_2 grid typically lets down some H_2 to the tail gas system for control, but excess H_2 may also be let down to LPFG. The H_2 grid pressure control program adjusts H_2 production to reduce H_2 letdown to LPFG, thus reducing the potential for flaring because of a fuel gas imbalance	Significant
Late 80's to present	Unit Flare Check Sheets were developed, implemented, and are periodically reviewed and updated. These check sheets are used by operators when the base-load to the Flare Gas Header is above its normal operating level. Use of these check sheets provides for a systematic search of potential gas streams that should not be flowing to the Flare Gas Header. During normal refinery operations, a reduction in flow to the Flare Gas Header does not reduce flaring because these gases are recovered during normal refinery operations. However, reducing or minimizing routine flows to the Flare Gas Header can reduce the quantity of flaring during a flaring event caused by maintenance activities, fuel gas imbalance, or an emergency event.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
Early 90's to present	Numerous comprehensive projects and improvements were implemented to allow longer runs between turnarounds. Most refinery projects include an element of improved reliability which increases run length. Examples of reliability improvement projects include upgraded metallurgy, improved designs, and equipment replacements. Shutdown and startup associated with turnarounds generate significant quantities of gas that result in flaring. Increased run length between maintenance turnarounds results in less frequent flaring events from unit shutdowns and startups.	Significant
1991	Developed an online computer tool (TDC Schematic 89) that displays on a single screen real-time operating data associated with flaring. This allows operators to quickly understand and troubleshoot flaring issues.	Moderate
~1992	Initiated procedures to balance flare loading during upsets/emergencies by equalizing South and North Flares to minimize excessive flaring and smoking at the South Flare. Flare balancing does not minimize the total quantity of flaring but does reduce emissions by improving flare performance during upsets/emergencies.	Minor
Mid 90's	Updated operating procedures to minimize flaring during loss of either the Coker Gas Compressor (C-902) or Cat Gas Compressor (C-701). Loss of either compressor results in significant flaring. The FCCU and CKR feed rates are reduced and the remaining compressor is used to fullest extent possible.	Significant

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
Mid to late 90's	Upgraded cooling water supply system for Cat Gas Compressor by providing cooling water booster pump. With this pumping configuration, condensing capacity was upgraded (E-707's) and interstage coolers (E-710's) on the Cat Gas Compressor were made more effective. These actions increased the capacity for condensing and recovering materials as liquids and reduced gas flows to the Flare Gas Header.	Moderate
1999 to present	Starting with the 1999 refinery-wide turnaround, a much higher emphasis was required for individual unit Process Coordinators of a major turnaround to minimize flaring by improving unit shutdown and startup procedures, scheduling, and flare balance. Additionally a Refinery Coordinator position was created for major turnarounds to work out plans to stagger unit shutdowns and startups to minimize flaring. Flaring was significantly reduced during the 1999 refinery-wide turnaround, and was then again significantly reduced during the 2004 refinery-wide turnaround by: 1) revising shutdown and startup procedures to minimize flaring from each process unit; and 2) improving the sequence of shutdowns and startups of all process units to reduce flaring to the extent practicable. Sequencing unit shutdowns and startups reduces the volume of gas flared at any time and increases recovery of flare gas. Figure 1 of the Executive Summary shows that flaring during the 2004 refinery-wide turnaround year was about half of what it was during the 1999 refinery-wide turnaround year. Turnaround length is typically set by available product coverage through exchanges and trades from alternate suppliers, and expected maintenance workload on major process units such as the PS, FCCU, and CKR. The shutdown and startup sequences are typically set by process and safety considerations. For example, during a Refinery-wide turnaround, the FCCU is shutdown after and started up before the CKR, in order for CKR gas to be processed in CLE rather than flared.	Significant

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
Late 90's to present	Utilized procedures that enable unit startup with minimum flaring. For example, the FCCU and associated CLE is started up before the CKR to allow CKR gas to be processed in CLE rather than flaring it. Also, the FCCU and CKR wet gas compressors are commissioned during startup to route FCCU and CKR vapors to CLE rather than to the Flare Gas Header.	Moderate
2000 to present	Increased/improved preventive maintenance on the Flare Gas Compressors (C-2101 A/B), which has resulted in improved reliability and less downtime. Recent activities have included cleaning and/or replacement of demisters pads. On-stream time for the compressors is generally at or exceeding industry standards for this type of compressor in dirty gas service. In the past, less maintenance was performed on the Compressors during shutdowns in order to get the Compressors back in service as soon as possible. Now, enhanced preventative maintenance is performed on each compressor when it comes down for maintenance, resulting in improved service factors and less major maintenance required. Increased service factor allows the Compressor to remain on-line longer to recover flare gas.	Moderate
2000 to 2005	Monitoring points for flow rates and temperatures were added to flare systems and added to the online computer tool for flaring (TDC Schematic 89). These changes provided more information and help to quickly trouble-shoot flaring issues.	Minor
2000 to 2002	Added overhead pressure control valves to towers (T-803 and T-805) at CLE. With the control valves, tower pressure can be slowly reduced in a controlled fashion to the Flare Gas Header rather than manually opening an 8-inch block valve which quickly releases gas to the Flare Gas Header.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2004	Rail Car Rack Vapor Recovery Project installed. Instrumentation controls were added to ratably control rail car loading and venting to the Flare Gas Recovery System, preventing flaring. The rate of depressuring rail cars to the flare header is controlled by monitoring flare header pressure to ensure the water seals at the flare drums are not broken, and all vapors in the flare header are recovered by the Flare Gas Compressors.	Moderate
2004	Rerouted Coker Gas from Coker Gas Compressor (C-902) to middle section of the CLE Absorber Deethanizer Tower (T-801). As a result, there was a reduction in the quantity of gas sent from CLE to the Fuel Gas Unit, thus reducing the potential for flaring because of a fuel gas imbalance.	Minor
2005	An automatic sampler was added to the flare system. This allows the refinery to better assess the flare gas quality consumed by the various fuel gas consumers, which helps minimizes flaring.	Minor
2006	Installed Pilot Operated Safety Valve on the CLE Heavy Cat Naphtha Steam Stripper Tower (T-807A) in order to raise tower operating pressure. When pressures are too high, this enables the tower overhead to be routed directly to the Fuel Gas Unit rather than to the Flare Gas Header, thus reducing load on the Flare Gas Compressors and the potential for flaring.	Minor
2006	Converted the cooling system for the Flare Gas Compressors (C-2101 A/B) from cooling water to glycol in 4Q2006. The objective of this project is to improve compressor reliability by converting the cooling system coolant to an independent, dedicated system that does not foul the compressor cooling system. Poor system cooling in the past has caused premature valve and piston problems, thus reducing the overall machine availability. This project will reduce the probability that both Flare Gas Compressors could be off-line at the same time, which would result in flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2006	The following specific measures were implemented to prevent reoccurrence of the failure of the make-up natural gas regulator which resulted in flaring in August 2006. The storage tank natural gas pressure regulator was temporarily closed and later repaired. The regulator performance is monitored as part of the tank compressor operations to ensure it is operating properly and not contributing flow to the fuel gas system. Piping line-ups were discussed and verified with on-shift personnel. These improvements will reduce the potential for flaring under the conditions that contributed to this flaring event.	Minor
2006	The following specific measures were implemented to prevent reoccurrence of the failure Refinery's Energy Isolation Procedure which resulted in flaring in October 2006. The Refinery's Energy Isolation Procedure was reviewed with the responsible technician and with the other operating personnel. The review ensures adherence to procedures that will minimize flaring.	Minor
2006	The following specific measures were implemented to prevent reoccurrence of the failure of the backup fuel gas recovery compressor solenoid valve which resulted in flaring in December 2006. In the event the backup fuel gas recovery compressor has a solenoid valve failure, a spare solenoid valve is maintained in storehouse stock. The on-site replacement spare enabled a timely replacement and restart of the back-up fuel gas recovery compressor. Automatic stock reorder points are established to ensure maximum availability for equipment repairs. Although vendor supply can affect delivery, Valero's system makes every attempt to restock in a manner that ensures spare availability and therefore increased reliability. These supply and reorder systems help minimize flaring by allowing back-up equipment to be available more quickly.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2007	Pre-Turnaround Flare Minimization Planning. Implemented a planning process for turnarounds that incorporates a review of the procedures to develop opportunities for flare minimization. This planning and review process has been consistently applied to turnaround operations and resulted in lessons learned for improved flare minimization techniques. These flare minimization techniques have been successfully applied at subsequent turnarounds of similar units. For example, Valero has developed revised shutdown procedures for hydroprocessing units to safely recover some of the low Btu gasses that are generated. These procedures originally developed at a single unit have been transferred to other similar units. The flare minimization improvement cycle will continue as this planning program evolves.	Moderate
2007	The following specific measures were implemented to prevent reoccurrence of the PG&E connection and synchronization failures which resulted in flaring in January 2007. PG&E Installed an AC undervoltage relay to supervise the operation of the DC undervoltage relay. Both relays require activation before the Valero Refinery breakers are tripped. The AC undervoltage relays are independent from each other and do not have a common point of failure.	Moderate

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2007	The following specific measures were implemented to prevent reoccurrence of fuel gas compressor failures which resulted in flaring in July 2007. The Fuel Gas Compressor valves were reengineered to provide an adequate safety margin for a full range of gases (molecular weight) sent to the online Fuel Gas Compressor under all operating conditions. The new valves were installed in the C2201A which was placed into primary service after its major maintenance and repairs on August 15, 2007. The new valves were installed in C2201B during maintenance scheduled for first quarter 2008. The Valero Refinery has recently implemented a predictive maintenance and performance testing program for both the C2201A and C2201B Fuel Gas Compressors, as well as other Valero Refinery compressors. The goal of this program is to identify potential problems, prior to an event such as a high discharge temperature trip.	Minor
2007	The following specific measures were implemented to prevent flaring from the Ultra Low Sulfur Diesel Unit (ULSD) that was brought online in July 2007. The impact of this new unit on actual flaring has been minimized by engineering the operation to significantly limit the circumstances under which the safety valves will be required to relieve. This is accomplished by over-engineering the major process vessels to allow them to withstand higher internal pressures than otherwise demanded by design codes. In so doing, the set pressures of the various relief valves have been raised. As a result, potential pressure events will be confined within the process vessels without lifting the safety valves and venting to the flare system.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2007	The following specific measures were implemented to prevent flaring from the C701 Check Valve failure in October 2007. In the interim period prior to the next "refinery-wide turnaround" scheduled for 2010, Valero has implemented procedures to ensure that the D-801 check valve will be blocked in whenever the Cat Gas Compressor (C-701) is out of service while the Cat Light Ends (CLE) unit is still in service. These revised operating procedures could help to minimize the likelihood of flaring during a "mid-cycle turnaround". Refer to 2011 update in FMP Table 2-1.	Minor
2007	The following specific measure was implemented to prevent flaring from the C701 Nozzle Control Wiring failure in November 2007. During the November 21, 2007 downtime, temporary jumpers were installed that enabled the A and B nozzle controllers to function properly. Refer to 2011 update in FMP Table 2-1.	Minor
2008	Catalyst Selection Planning. Implemented a Catalyst Selection review process that standardizes the selection process. Catalyst selection depends on equipment requirements and maintenance planning and scheduling coordination. A standardized selection process ensures that opportunities for flare minimization are assessed at the early planning stages.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2008	The following specific measures were implemented to prevent flaring from the LCNHF Shutdown in June 2008. All feasible prevention measures were incorporated into the planned procedures for conducting the maintenance activities that resulted in this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP) (Rev. 2, submitted on March 16, 2007, updated March 28, 2007 and July 13, 2007). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in the causal analysis report. During the post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. There were no additional prevention measures that were feasible or practical which could further minimize or eliminate flaring from this planned maintenance activity.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2008	The following specific measures were implemented to prevent flaring from the CFHU Turnaround in October and November, 2008. All feasible prevention measures were incorporated into the planned procedures for conducting the maintenance activities that resulted in this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP updated March 28, 2007 and July 13, 2007 and Rev. 3.1 submitted on September 16, 2008). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in the causal analysis report. During the post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. There were no additional prevention measures that were feasible or practical which could further minimize or eliminate flaring from this planned maintenance activity.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2009	The following specific measures were implemented to prevent flaring from the shutdown operations at the HCU in March, 2009. All feasible prevention measures were incorporated into the planned procedures for conducting the maintenance activities that resulted in this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP) (Rev. 2, submitted on March 16, 2007, updated March 28, 2007 and July 13, 2007). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in Section 12 of the applicable causal analysis report. During our post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor
2009	The following specific measures were implemented to prevent flaring from the lifting of the safety valves on the Dimersol feed cooling circuit that occurred in March 2009. Once these valves lifted, they did not completely reseat and continued to leak to the flare header. The following prevention measures were implemented for the flaring event. A. Operations replaced the safety valves with storehouse spares and re-commissioned the newly installed safety valves. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2009	The following specific measures were implemented to prevent acid gas flaring due to opening of T-2801 bypass valve and over-pressuring of TK-2801 in April 2009. A majority of the flaring and the resulting emissions from this event were caused by opening the bypass valve around T-2801 overhead pressure control valve [28P053CV(B)] to the Acid Gas Flare. When the bypass valve was discovered open on April 6, the valve was immediately closed. The primary cause of this flaring was the technician failing to understand his work task and failing to make the correct lineup in the field. As a result, operations supervision has a discussion with the technician regarding the flaring event, emphasizing the importance of clear understanding of the task to be conducted, and confirming line-ups in the field before taking any action. The unclear radio communications that resulted in the misunderstanding between the two valves ("P" and "F") was determined to be a contributing factor that by itself should not have resulted in flaring. Unclear radio communications have not historically caused similar problems and corrective action for improved communication was determined not to be warranted. TK-2801 vapors were manually vented to the Acid Gas Flare in order to prevent the tank safety valves (in sour gas service) from releasing. This flaring was result of an emergency and was necessary to prevent a release to the atmosphere This valve [28P056CV] was opened three times for a total of 29 minutes on April 6 to control tank pressure. The total flow of acid gas to the flare from TK-2801 was less than 0.007 MMSCF and emissions were 76 pounds of SO_2. Flaring in order to prevent an atmospheric release is consistent with Valero's FMP and Regulation 12-12. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2009	The following specific measures were implemented to prevent flaring from the shutdown operations at the LCNHF in July 2009. All feasible prevention measures were incorporated into the planned procedures for conducting the maintenance activities that resulted in this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP) (Revision No. 3.2, July 16, 2008 (Revised September 16, 2008 and April 17, 2009)). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in Section 12 of the applicable causal analysis report. During a post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2009	The following specific measures were implemented to prevent flaring from the shutdown operations at the HCU in August 2009. All feasible prevention measures were incorporated into the planned procedures for this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring following planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP) (Rev. 3.2, submitted on July 16, 2008, and updated on September 16, 2008 and April 17, 2009). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in Section 11 and 12 of the applicable causal analysis report. During our post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Based on the maintenance project criteria, it was not necessary to completely depressurize the unit, Ni-cool it or prepare it for entry. The limited project criteria minimized the amount of flaring normally associated with a HCU shutdown. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor
2009	The following specific measures were implemented to prevent flaring from the operations at C2101B in September 2009. Operations repaired the valve. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2009	The following specific measures were implemented to prevent flaring from the shutdown operations at the CFHU in November/December 2009. All feasible prevention measures were incorporated into the planned procedures for this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring following planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP) (Rev. 3.2, submitted on July 16, 2008, and updated on September 16, 2008 and April 17, 2009). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in Section 11 and 12 of the applicable causal analysis report. During a post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2009	The following specific measures were implemented to prevent flaring from the startup operations at the HCU in December 2009. All feasible prevention measures were implemented and are described in Section 12 of the applicable causal analysis report. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Based on the maintenance project criteria, it was not necessary to completely depressurize the unit, Ni-cool it or prepare it for entry. The limited project criteria minimized the amount of flaring normally associated with a HCU shutdown. The low flow and emissions from this event were the result of the flare minimization efforts, however the H_2S concentration of the flare sample for this event was higher than expected based on engineering design calculations. The SO_2 calculations are based on a single grab sample that may not be representative of the entire flare event. During the next HCU turnaround, additional flare gas samples and process stream samples will be collected to investigate the H_2S sources and concentrations. This activity may result in a more representative H_2S and SO_2 accounting and perhaps identify future prevention measures. There were no additional prevention measures that were feasible or practical which could further minimize or eliminate flaring from this planned maintenance activity.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2010	The following specific measures were implemented to prevent flaring from the shutdown operations at the DHF in January 2010. All feasible prevention measures were incorporated into the planned procedures for this flaring event. These prevention measures helped to minimize flaring but were not able to prevent the flaring event. Prevention measures to minimize and potentially eliminate flaring following planned maintenance activities are described in detail in Section 5.1 of Valero's approved Flare Minimization Plan (FMP) Valero Refinery's approved FMP (Revision No. 4, October 1, 2009). In accordance with the FMP, pre-maintenance planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. All feasible prevention measures were implemented and are described in Section 11 and 12 of the applicable causal analysis report. During a post-maintenance review of the flaring event, no additional prevention measures were identified. The maintenance activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. There were no prevention measures that were feasible or practical to eliminate this flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2010	The following specific measures were implemented to prevent flaring from the T-2831 Turnaround in May 2010. Operations blocked in the valve and removed it for testing and performance specifications review. The vendor repairs to this valve resulted in valve position settings that were incorrect for this service application. The faulty valve was replaced with one that had the correct settings for this service application. The contractor responsible for maintaining and verifying the Panametric Flare Flow Meter operation was brought onsite to assess the operation of the Acid Gas Flare Flow meter. It was determined that it was operating normally. Additionally, the contractor conducted the regularly scheduled flow verification for all the Panametric Flare Flow Meters in the first week of June 2010. Again the contractor determined that the flow meters had been properly operating during the event. A baseline level of noise is normally expected in both the raw and pressure validated flow measurement. The meter is operated and maintained in accordance with BAAQMD Regulation 12-11-501. The Turnaround procedures and review have been updated with additional checks to ensure equipment sent out for repair meets the required specifications for the service application. Additional procedures, checklists and training were developed, communicated and implemented to the operations employees to improve troubleshooting flows to the Acid Gas flare.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2010	A new Butamer Unit (BTR) was installed in February 2010 at the Benicia Refinery. This unit should reduce potential flaring from the Alkylation Unit by providing a more reliable source of isobutane to Alky. Flare minimization steps associated with major maintenance activities, including startup and shutdown, have been developed. The Benicia Refinery has generic experience starting and shutting down other units and used this experience to establish the initial Butamer procedures. The procedures will be refined and improved based on specific experience with the new unit in service.	Minor
2010	A new CARB Phase III Modifications project was installed in April 2010 at the Benicia Refinery. These changes will reduce flaring by maintaining the run lengths of the HCNHF and LCNHF at the higher operating severities necessary to meet the tighter gasoline specifications. Flare minimization steps associated with major maintenance activities, including startup and shutdown, have been developed. The Benicia Refinery has generic experience starting and shutting down similar equipment and used this experience to develop the initial equipment procedures. However, the procedures will be refined and improved based on specific experience with the new equipment once it is placed into service.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2010	The following specific measures were implemented to prevent flaring from the shutdown operations at the Alky Unit in July 2010. Operating procedures were updated to provide additional specific information on the Alky reaction zone chemistry and troubleshooting. The Alky normal and operating procedures were reviewed using feedback from the event investigation. The unit manufacturer was also brought on site to make recommendations for future implementation for the Alky equipment. The manufacturer had only minor recommendations to the procedures, none of which would have prevented the event from occurring. 22 alarms were added/changed to alert operators of falling acid strength, carryover of water, side reactions, poor neutralization, and acid carryover, as these were recognized as potential acid runaway indicators. Supplemented training on Alky acid runaway identification and emergency procedures. Refresher computer based training was conducted as well as a training course from the manufacturer.	Minor
2010	The following specific measures were implemented to prevent flaring from the C-101C and C-2101B maintenance in August 2010. A work order was generated to conduct maintenance on C-2101B. Because the work can only be completed while the compressor is shutdown, the work is scheduled for a later date when there would be less planned activity in the flare header. Opportunistic scheduling decreases the chance of flaring due to one operational flare gas compressor and therefore increases the flare load recovery.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2010	The following specific measures were implemented to prevent flaring from the operational difficulties of C-2101A/B in August 2010. On August 31st, Valero's electrical contractor responded to the C-2101A trip and reset the DR relay inside the 4160v starter. On September 1st, I/E replaced a transmitter and relocated tubing as part of maintenance on C-2101A.	Minor
2010	The following specific measures were implemented to prevent flaring from the GT-401 trip at the HCU in September 2010. The 2.5 amp fuse was replaced with a 5 amp fuse. The Triconex logic was corrected in all four turbines (GT-401, GT-701, GT-702, and GT-1031) so that the logic that causes the compressor to trip on loss of three flame scanners will only be used during the startup period. The supply circuit design and associated input output circuits will be reviewed. The following items will be evaluated during the review: • having two independent power sources, • breaker sizing, • fuse sizing, • power failure alarms, • independent fusing for each input/output, • verifying components have redundant power sources, • scheduling PM program on power modules, • testing redundant uninterruptable power supply feeds.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2010	The following specific measures were implemented to prevent flaring from the refinery-wide shutdown operations in December 2010. There were no additional prevention measures beyond those listed in FMP Table 4.2 that are feasible or practical which can further minimize or eliminate flaring from this planned maintenance activity. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. Planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. Prior to the event, months of scheduling had been done for the planned turnaround. An environmental engineer met with each unit and went over all procedures that would be used during shutdown and startup for the unit. Taking this information, and keeping within the restraints of the refinery design (i.e. staggered refinery-wide shutdown due to integration of units) the environmental engineer documented all procedure steps that would result in flaring and made suggestions to minimize flaring when possible. Unfortunately due to the unplanned shutdown of the FCCU in early December, the turnaround timeline was not able to be executed as planned. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The maintenance activities on the flare gas recovery compressors were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2011	The following specific measures were implemented to prevent flaring from the refinery-wide turnaround and startup operations in January through March 2011. Review procedures to address high volumes of heavier hydrocarbon vapors (C5 hydrocarbons) to the flare header. A training CBT was issued following that event and is set as a reoccurring refresher training. There were no additional prevention measures beyond those listed in FMP Table 4.2 that were feasible or practical which could further minimize or eliminate flaring from this planned maintenance activity. All feasible prevention measures were incorporated to the extent feasible for the event. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Section 4.1 of Valero's approved Flare These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. Planning was conducted to identify prevention measures to minimize and potentially eliminate flaring. During our post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The maintenance activities on the flare gas recovery compressors were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2011	The following specific measures were implemented to prevent flaring from the C-302D trip in March 2011. Upon investigation, the underground control cable to the C-302D motor was found to be shorted. The cable ran next to the fire water main which had been excavated for maintenance. The investigation determined that the cable was most likely damaged while the piping in this area was being excavated. A temporary cable was run above grade and the compressor was restarted. Evaluate rerouting the control cable when the permanent cable is ready to be installed.	Minor
2011	The following specific measures were implemented to prevent flaring from operations due to closed in-line analyzer valves at the H2U in April 2011. There were no additional prevention measures beyond those listed in FMP Table 4.2 that were feasible or practical which could further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Section 4.1 of Valero's approved Flare Minimization Plan.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2011	The following specific measures were implemented to prevent flaring from operations in July 2011. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, the following additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. • Communicated the requirement to follow range guidelines in the approved CIC check procedures. This statement was already in place in the long-term orders (Standing Orders) prior to the event, but the statement was added to the daily orders (Night Orders).	Minor
2011	The following relates to flaring from operations in September 2011. There are no additional prevention measures beyond those listed in FMP Table 4.2 that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2011	The following relates to flaring from operations in October 2011. (GT-701) There are no additional prevention measures beyond those listed in FMP Table 4.2 that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor
2011	The following relates to flaring from operations in October 2011. (C2101) There are no additional prevention measures beyond those listed in FMP Table 4.2 that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2012	The following specific measures were implemented to prevent flaring from operations in February 2012. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, the following additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. • The control valve (CVL012) was replaced • Upgrade valves in the CVL012 bypass loop during the next CFHU turnaround • Because the DIM startup was a result of a DIM shutdown for maintenance work, the following prevention measures were implemented to prevent reoccurrence related to the shutdown and thus the related startup: • The circuit of piping where the leak occurred was replaced; • The location were the leak occurred has been added to a more rigorous inspection schedule; • Similar piping circuits were evaluated for similar isolated damage.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2012	The following relates to flaring from operations in August 2012. (HCU) Valero will review the procedures to align the requirements for the re-introduction of feed following a feed pump trip (temperature, Fractionator level, etc) and this may lead to improved unit restart and reduced flaring. All feasible prevention measures were incorporated into the planned procedures for this flaring event. There are no additional prevention measures beyond those listed in FMP Table 4.2 that can further minimize or eliminate flaring from this event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2012	The following relates to flaring from operations in November 2012. (HCU) All feasible prevention measures were incorporated into the planned procedures for this flaring event. There are no additional prevention measures beyond those listed in FMP Table 4.2 that can further minimize or eliminate flaring from this event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor
2012	The following relates to flaring from Turnaround operations in November 2012. (VNHF) All feasible prevention measures were incorporated into the planned procedures for this flaring event. There are no additional prevention measures beyond those listed in FMP Table 4.2 that can further minimize or eliminate flaring from this event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2013	The following relates to flaring from Turnaround operations in February 2013 (HCNHF, H2U-A, DHU, CFHU). All feasible prevention measures were incorporated into the planned procedures for this flaring event. There are no additional prevention measures beyond those listed in FMP Table 4.2 that can further minimize or eliminate flaring from this event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor
2013	The following relates to flaring from Turnaround operations in March 2013 (HCNHF, H2U-A/B, DHU, CFHU, HCU). All feasible prevention measures were incorporated into the planned procedures for this flaring event. There are no additional prevention measures beyond those listed in FMP Table 4.2 that can further minimize or eliminate flaring from this event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. During a post-incident review of the flaring event, no additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring. Prevention measures to minimize and potentially eliminate flaring from planned maintenance activities are described in detail in Valero's approved Flare Minimization Plan.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2013	The following relates to flaring from upset operations in May 2013 (SRU). During a post-incident review of the flaring event, the following additional prevention measures were identified in order to prevent a similar flaring event from reoccurring in the future. Specific measures that were implemented to prevent reoccurrence related to this incident include: • Cleaned or replaced system strainers and steam traps to improve flow in the condensate system. • Communicated tower flow obstruction conditions to Control Board Operators. • Installed a rich MEA filter to remove particulate and reduce restriction propagation.	Minor
2013	The following relates to flaring from upset operations in June 2013 (FCCU). The following prevention measure was identified and is being implemented to reduce the likelihood of a recurrence of the type of reportable flaring event that occurred: • Reviewed setpoints and procedures for setpoint changes. • Communicated summary of incident to Control Board Operators (CBOs) • Communicated procedures for setpoint changes to CBOs. For flaring associated with unit shutdown and startup, all feasible prevention measures have been incorporated into Valero's written procedures. Shutdown and startup activities were conducted in accordance with Valero's written procedures that were designed in part to minimize flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2014	The following relates to flaring from upset operations in April 2014 (FCCU). Added clarification step to the GT-701 gas turbine startup procedure after maintenance downtime that more clearly explains the fuel gas control valve lineup prior to turbine startup. Included a review of proper fuel gas control valve lineup to the gas turbines in the curriculum for the next Unit Refresher training class.	Minor
2014	The following relates to flaring from unit shutdown April 2014 (FCCU). There are no additional prevention measures that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor
2014	The following relates to flaring from upset operations in June and July 2014 (HPFG loss). There are no additional prevention measures that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible for the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor
2014	The following relates to flaring from unit startup July – August 2014 (FCCU). The FCCU C-701 shut down and start up procedures were modified to reflect proper T-102 overhead line-up.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2015	The following relates to flaring from unit shutdown and startup from January-March 2015 (LCNHF, NRU, HCU, HSU). There are no additional prevention measures that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent feasible during the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor
2015	The following relates to flaring from unit shutdown and startup in March 2015 (HCU). To address the primary cause of the flare event due to high temperature trip while manually adjusting the hot gas bypass valve, the Night Orders have been updated with guidance on options (other than manual adjustment of the bypass valve) that may be used to reprofile reactors. To address the frozen control valve, many potential measures have been identified to improve the function of the automated control valve (such as additional inspections, procedures, and revised designs). These measures are currently under review. Feasible improvement measures will be incorporated when the control valve is repaired, rebuilt, or replaced at the next scheduled unit downtime.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2015	The following relates to flaring from operations in August 2015 (C-2101). A. Once C-2101A was repaired and brought online, C-2101B was pulled for maintenance. Repairs to C-2101B included replacing all valves. B. Compressor valves typically last 6–18 months depending on the gas composition being compressed. Due to the wide life span range, preemptive replacement of the valves is not feasible because it would increase the amount of time the compressor is out of service for maintenance, thereby reducing the amount of time a backup compressor is available and further increasing the probability of having both compressors out of service at the same time. C. The cause of the early August 2015 high hydrogen content in the flare gas header was investigated but a specific explanation was not found.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2015	The following relates to flaring from operations in October 2015 (PS). • Stop all work at the pump shop • Regarding improved warm-up/clearing facilities, an engineering evaluation determined that those would minimized damage to equipment but would not prevent a unit shutdown. For this reason, Valero has decided not to implement the project at this time.	Minor
2015	The following relates to planned startup in October 2015 (CFHU). There are no additional prevention measures that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent possible during the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor
2016	The following relates to planned shutdown in January 2016 (CFHU). There are no additional prevention measures that are feasible or practical which can further minimize or eliminate flaring from this event. All feasible prevention measures were incorporated to the extent possible during the event. These immediate actions and prevention measures helped to minimize flaring but were not able to prevent the flaring event. The activities were conducted in accordance with Valero's planned procedures that were designed in part to minimize flaring.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2016	The following relates to flaring from operations in March 2016 (North Flare). The refinery's flare stacks were not designed with purge gas. A continuous natural gas purge would prevent oxygen intrusion and eliminate a flammable environment. A. <u>Initiated a natural gas purge to the north flare prior to restart</u> The north flare stack has an existing natural gas line near the base of the stack that was installed as a back-up source of fuel to the pilots. The location is suitable for re-purposing the line as a continuous purge. The natural gas purge was initiated on March 23, 2016, prior to the deblinding of the north flare to the flare header. B. <u>Initiated monitoring of oxygen concentration in the south flare stack</u> An existing natural gas line does not exist near the base of the south flare stack. Until a natural gas purge on the south flare system can be installed, the oxygen concentration is monitored. If above 4% O_2 the DCS alarms and a nitrogen purge is turned on to reduce the oxygen concentration. C. <u>Install natural gas purge in both north and south flare drums</u> A long term project is being considered and scoped to install natural gas purges in the north and south flare seal drums above the liquid level so that all space downstream of the liquid seal is purged.	Significant

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2017	The following specific measures were implemented to prevent flaring from the shutdown operations at the HCU due to a crack in the HCU furnace outlet piping in April 2017. • The pipe was repaired. Repairs include replacing the whole elbow and spool, including the stub out. • Piping stress at the leak location was found to be under the code-allowable stress (no anomalies). The failed pipe has been sent out for testing and analysis to determine the exact mechanism of failure. The results will be considered for future potential design recommendations.	Minor
2017	The following specific measures were implemented to prevent flaring from the sudden loss of electrical power supply from Pacific Gas & Electric (PG&E) in May 2017. • An ongoing, attorney-client privileged investigation with PG&E and Valero will identify any corrective action steps to reduce the likelihood of recurrence.	Minor

Year Installed/ Implemented	Equipment Added, Process Changed, or Procedure Implemented	Minimization of Flaring
2018	The following specific measures were implemented to prevent flaring from the Cat Feed Hydrofiner Unit trip due to a leak from the engineered enclosure around piping at 6L016-CV in May 2018. • Evaluated the use of a triple groove perimeter seal design for high pressure service • Create an engineered temporary repair PSSR checklist to supplement the condensed PSSR form	Minor
2018	In 2018, there has been a significant reduction in flaring due to adjustments made to the north and south flare water seal drums and the flare gas recovery compressors in order to increase the optimization of the flare recovery system. The changes have increased the amount of backpressure required to overcome the water seals and provides more opportunity for the flare gas recovery compressors to recover smaller volumes routed to the flare system.	Significant

This EHSM incident and investigation process is used to implement the evaluation of cause and contributing factors, consideration of measures to minimize flaring, and recurrent failure evaluation described in Section 2.3.2 and depicted in Figure 8 – Flare Minimization Flowchart for Maintenance. Approximately 800 incidents are generated per year. The EHSM system drives continuous improvement in personnel and operational safety, reliability and environmental compliance, and directionally reduces flaring. It is imperative to understand and learn from incidents that are outside the norm. The current version of this process, including the use of Cause Mapping© was implemented in 2011, and the system is documented in the refinery Accident Prevention Manual (APM 1-4-0).

- **Materials Operating Envelope (MOE) Reliability System.** The MOE reliability system is a management system that was identified for implementation in the refinery-wide reliability study completed in 2004/2005. The objective of the system is to eliminate equipment failures related to materials of construction failures by helping to stay within operating parameters so that corrosion is minimized. Flaring is reduced as a result of this system for two primary reasons. First, a reduction in equipment failure will reduce the frequency of emergency process unit shutdown, maintenance, and subsequent startup, all of which can cause flaring. Secondly, improved corrosion management will ultimately reduce the frequency of unplanned shutdown, maintenance, subsequent startup to correct a corrosion issues.

  With the MOE reliability system, detailed evaluations are performed on each process unit to verify that the appropriate metallurgy is in place for the materials processed and the operating conditions (pressure, temperature, etc) under which the equipment operates. The results of the MOE reviews are then incorporated into the refinery corrosion monitoring program, which is stewarded by operations and technical personnel. For example, the MOE reliability system indicated that the HCU reactor effluent piping should be inspected. The inspection found that the piping was corroding faster than anticipated. The piping was replaced with alloy lined piping during a scheduled HCU maintenance turnaround, thereby avoiding a potential unscheduled HCU downtime with associated flaring.

4.2 Specific Improvements that Result in Flare Minimization

Table 4-1 provides specific flare minimization measures for the Benicia Refinery. For each measure, the anticipated year of installation or implementation is provided. Additionally, the effectiveness of the these measures in minimizing the frequency and magnitude of flaring events is qualitatively shown as “significant”, “moderate”, or “minor”.

5. Prevention Measures

In accordance with Regulation 12-12-401.4 this section of the FMP provides a discussion of prevention measures that the Benicia Refinery has considered for implementation. The discussion provides general background and specific information regarding various refinery activities that impact the recoverability of refinery fuel gas in the Flare Gas Recovery System. Based on a review of flaring that has occurred historically at the Benicia Refinery, a summary is provided of measures that the refinery has considered for minimizing flaring from maintenance activities including a determination as to the feasibility and effectiveness of the considered approaches. Where approaches have been identified as being feasible and effective they have subsequently been incorporated into normal refinery operations. Measures that have been evaluated but determined not to be feasible or effective are also discussed, along with supporting information for the infeasibility and ineffectiveness.

5.1 Prevention Measures – Maintenance Activities

In this section, refinery maintenance including startup, shutdown, and turnaround activities are discussed, and measures that have been considered to minimize flaring during planned and unplanned maintenance activities are reviewed. Section 2.2.1 provides a summary of reasons for flaring as a result of maintenance activities.

The evaluation of prevention measures to reduce flaring as a result of maintenance is primarily based upon a review of the historical causes of flaring events, especially those that have occurred during the last five years. The Benicia Refinery has expended significant effort to reduce sources of flow to the Flare Gas Header from these activities. The refinery's evaluations have concluded that modifications to operational, planning, and maintenance approaches are a more feasible and effective strategy than major capacity additions to the existing Fuel Gas Unit (as discussed in Section 5.2).

In accordance with Regulation 12-12-401.4.1, the evaluation of prevention measures presented in this section is based on a review of flaring events that have occurred during maintenance activities in the last five years. These events are presented along with a summary of the measures that have been considered, and in many cases, where practical and feasible, implemented to reduce the flow of gases to the Flare Gas Recovery System.

In this section, prevention measures are not considered for the Acid Gas Flare because there are no major maintenance activities which utilize the Acid Gas Flare. The Acid Gas Flare is primarily used for emergency and upset conditions, and some startup and shutdown conditions. Outside of emergency and upset conditions, the Acid Gas Flare has limited use. For example, during turnarounds at the SGU, various equipment, such as pumps, vessels, and exchangers, is drained, washed, and then steamed to the Acid Gas Flare. During startup and shutdown of the SGU, relatively small quantities of liquid in various lines are blown down to the Acid Gas Flare system (liquids are removed at the SGU Liquid KO Drum and gasses are sent to the Acid Gas Flare). Regular maintenance procedures for reflux pumps in sour water recirculation service require that the Acid Gas

For equipment containing residual hydrocarbon liquid, steam or nitrogen is often used to "blow" the liquid to the knockout drums typically located near the process units. The liquid hydrocarbons (and water if steam purging is used) are then separated from the vapor phase in the knockout drum. The liquid phase is typically returned to the refinery's recovered oil system where the water is separated from the oil and sent to wastewater treatment, and the oil is re-processed in the PS, FCCU, or CKR. The gas phase, typically nitrogen with hydrocarbon vapor, continues on to the Flare Gas Recovery System. Once the bulk of the liquid hydrocarbon has been displaced, the flow of steam or nitrogen is continued to remove any residual hydrocarbon by vaporization.

If heavier hydrocarbon materials are present, different strategies are often used. Steam can be more effective than nitrogen or inert gases for heavier materials, as it increases their volatility by increasing temperature. Hot hydrogen is used in some processes to "hot strip" hydrocarbons off of catalyst beds. Proprietary solvents such as "Zyme-flow" or other chemical washing agents are also sometimes used in aqueous solution ("liquid phase chemical cleaning") for removal of residual hydrocarbons. When aqueous solvents are used, they are typically circulated in the equipment and then treated. Steam may be used in combination with a chemical cleaning agent ("vapor phase chemical cleaning") to clear heavy materials from equipment. Vapor phase chemical cleaning may also be used together with liquid phase chemical cleaning.

Implementing these procedures has resulted in the capture of significant hydrocarbon emissions related to equipment opening that previously were released untreated to the atmosphere. However, in many circumstances these practices require a high volume and high velocity flow of steam or nitrogen to be effective. High flow rates of inert gas can create several sets of circumstances where flare gas recovery may not be possible. These problems typically relate either to the change in fuel gas composition (molecular weight), condition (temperature), or high rate of flow as discussed in the following section.

5.1.2 Flaring During Major Maintenance Activities

Table 5-1 provides a summary of flaring events that have occurred as a result of major maintenance activities during the past five years. Table 5-1 was prepared by comparing flaring data and process unit records for planned turnarounds to conduct major maintenance. In Section 4.1.2, prevention measures are evaluated to minimize the flaring events identified by this five-year lookback along with any other flaring that may reasonably be expected to occur as a result of major maintenance activities.

Starting on August 20, 2005, a flaring event was defined as a vent gas flow rate 0.5 mmscfd or more and prior to this date, a flaring event was defined as a vent gas flow rate of 1 mmscfd or more. In accordance with Regulation 12-11-501, vent gas meters were installed at each flare during the first quarter of 2004. Prior to installation of these flow meters, the data used to prepare Table 5-1was obtained from flow meters that were not required or approved by the BAAQMD.

Date	Process Unit	Description of Activity Resulting in Flaring
None in the last 5 years.	JHF	During unit shutdown, hot strip vessels with H2 then N2. During unit shutdown, cool reactor (and purge downstream vessels) with N2. If necessary to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N2 then release. During unit startup, warm reactor with hot H2. During unit startup, activate catalyst with H2.
None in the last 5 years.	DHF	During unit shutdown, hot strip vessels with H2 then N2. During unit shutdown, cool reactor (and purge downstream vessels) with N2. If necessary to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N2 then release. During unit startup, warm reactor with hot H2. During unit startup, activate catalyst with H2.
None in the last 5 years.	VNHF	During unit shutdown, hot strip vessels with H2 then N2. During unit shutdown, cool reactor (and purge downstream vessels) with N2. If necessary to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N2 then release. During unit startup, warm reactor with hot H2. During unit startup, activate catalyst with H2.

Date	Process Unit	Description of Activity Resulting in Flaring
February 2014	DIM	During unit shutdown, depressure vessels. During unit shutdown, to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N2, then release. During unit startup, send off-spec products to the Flare Gas Header.
None in last 5 years	ALKY	During unit shutdown, depressure vessels. During unit shutdown, to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N2 then release. During unit startup, send off-spec products to the Flare Gas Header.
February 2014	CKR PS (Vacuum Column) & CFHU	During unit shutdown, depressure products to the Flare Gas Header. During unit shutdown, to meet vessel depressurization requirements (Regulation 8-10), strip vessels with steam. During unit startup, send off-spec products to the Flare Gas Header.
February 2015 February 2014 September 2013	MRU HSU (Heartcut Saturation Unit)	During unit shutdown, hot strip vessels with H2, then N2. During unit shutdown, cool reactor (and purge downstream vessels) with N2. If necessary to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N2, then release. During unit startup, activate/dry catalyst with N2, then H2.

practices have already been implemented (see Table 3-1 in Section 3) or are planned (see Table 4-1 in Section 0).

The Benicia Refinery's reduced flaring (as documented in the executive summary) has been primarily achieved by focusing on continual improvement with respect to (1) planning and preparation for maintenance activities; (2) equipment reliability improvements which both decrease the frequency of flaring caused by emergencies and unplanned maintenance and decrease the frequency of planned maintenance by increase process unit run length between major maintenance activities; and (3) proactive initiation of production cuts to reduce fuel gas production when a fuel gas imbalance is anticipated. As a standard practice and in accordance with the FMP process, the Benicia Refinery will continually evaluate additional potential prevention measures and implement the ones that are feasible and practical.

Table 5-2 provides a summary of the Benicia Refinery's evaluation of additional prevention measures that could minimize or eliminate maintenance-related flaring than can reasonably be expected to occur. For prevention measures that have been determined to be practical and feasible, a schedule for expeditious implementation is provided in the right hand column of Table 5-2.

Table 5-2 – Evaluation of Prevention Measures to Minimize or Eliminate Maintenance Flaring

Maintenance Activity and Process Units	Description of Prevention Measure	Feasibility/ Implementation Schedule
Depressure hydrocarbon containing vessels to Flare Gas Header during shutdown of HCU, NRU, DIM, ALKY, CKR, PS, FCCU, CLE, VLE, LCNHF, HCNHF, CFHU, JHF, DHF, VNHF, ULSD, BTR, and MRU	Minimize flaring through maintenance planning and preparation (see Section 4.1.4).	Formal maintenance planning procedures were implemented in 2007 and will continue to be updated as experience is gained.
	Minimize or eliminate flaring by expanding the existing Flare Gas Recovery System.	Not cost-effective as documented in Section 4.2.2.2.
Hot strip reactors with H_2 then N_2 during shutdown of LCNHF, HCNHF, CFHU, JHF, DHF, VNHF,	Minimize flaring through maintenance planning and preparation (see Section 4.1.4).	Formal maintenance planning procedures were implemented in 2007 and will continue to be updated as experience is gained.

Maintenance Activity and Process Units	Description of Prevention Measure	Feasibility/ Implementation Schedule
	Minimize or eliminate flaring by expanding the existing Flare Gas Recovery System.	Not cost-effective as documented in Section 4.2.2.2.
Cool reactors (and purge downstream vessels) with N_2 during shutdown of LCNHF, HCNHF, CFHU, JHF, DHF, VNHF, ULSD, HCU, MRU, BTR, and ALKY	Minimize flaring through maintenance planning and preparation (see Section 4.1.4).	Formal maintenance planning procedures were implemented in 2007 and will continue to be updated as experience is gained.
	Recycle N_2 within the reactor and minimize that quantity of gas that is purged to the Flare Gas Header. This practice is currently utilized at the CFHU, JHF, ULSD, HCU, and NRU because these units include recycle gas compressors as an inherent part of the reactor circuit design. Therefore, consideration of this prevention measure only applies to the LCNHF, HCNHF, DHF, VNHF, MRU, BTR, and ALKY.	Based on the design of the Benicia Refinery, it is not technically feasible to recycle N_2 at the LCNHF, HCNHF, DHF, VNHF, MRU, BTR, and ALKY. These units are not designed for recycle and do not have recycle gas compressors.
	Route the low Btu gases (N_2) to the Fuel Gas Unit and add natural gas to meet Btu specifications for fuel gas.	The use of natural gas to increase Btu content is not technically feasible because the quantity of natural gas needed would cause a fuel gas imbalance which would still result in flaring.

Maintenance Activity and Process Units	Description of Prevention Measure	Feasibility/ Implementation Schedule
If necessary to meet vessel depressurization requirements (Regulation 8-10), pressure vessels with N_2 then release and/or strip vessels with steam during shutdown of LCNHF, HCNHF, CFHU, JHF, DHF, VNHF, ULSD, HCU, NRU, MRU, DIM, ALKY, CKR, PS, FCCU, CLE, and VLE	Minimize or eliminate flaring through maintenance planning and preparation (see Section 4.1.4).	Formal maintenance planning procedures were implemented in 2007 and will continue to be updated as experience is gained.
	Minimize or eliminate flaring by expanding the existing Flare Gas Recovery System.	Not cost-effective as documented in Section 4.2.2.2.
Warm reactors with hot H_2 during startup of LCNHF, HCNHF, CFHU, JHF, DHF, VNHF, ULSD, HCU, NRU, MRU, and ALKY	Minimize flaring through maintenance planning and preparation (see Section 4.1.4).	Formal maintenance planning procedures were implemented in 2007 and will continue to be updated as experience is gained.
	Recycle H_2 within the reactor and minimize that quantity of gas that is purged to the Flare Gas Header. This practice is currently utilized at the CFHU, JHF, ULSD, HCU, and NRU because these units include recycle gas compressors as an inherent part of the reactor circuit design. Therefore, consideration of this prevention measure only applies to the LCNHF, HCNHF, DHF, VNHF, MRU, and ALKY.	Based on the design of the Benicia Refinery, it is not technically feasible to recycle H_2 at the LCNHF, HCNHF, DHF, VNHF, MRU, and ALKY. These units are not designed for recycle and do not have recycle gas compressors.

Maintenance Activity and Process Units	Description of Prevention Measure	Feasibility/ Implementation Schedule
	Recycle N_2 within the reactor and minimize that quantity of gas that is purged to the Flare Gas Header. This practice is currently utilized at the CFHU, JHF, ULSD, HCU, and NRU because these units include recycle gas compressors as an inherent part of the reactor circuit design. Therefore, consideration of this prevention measure only applies to the LCNHF, HCNHF, DHF, VNHF, MRU, and ALKY.	Based on the design of the Benicia Refinery, it is not technically feasible to recycle H_2 at the LCNHF, HCNHF, DHF, VNHF, MRU, and ALKY. These units are not designed for recycle and do not have recycle gas compressors.
	Route the low Btu gases (N_2) to the Fuel Gas Unit and add natural gas to meet Btu specifications for fuel gas.	The use of natural gas to increase Btu content is not technically feasible because the quantity of natural gas needed would cause a fuel gas imbalance which would still result in flaring.
	Segregate low Btu gases (N_2) and routine base-load flare gases. Route the low Btu gases to the flare and the routine base-load flare gases to fuel gas recovery.	Based on the design of the Benicia Refinery, it is not technically feasible to segregate the low Btu gases and routine base-load flare gases. Additionally, even if this could be accomplished, flaring would not be reduced because fuel gas needs to be added to the low Btu gases to ensure effective combustion at the flares.

Maintenance Activity and Process Units	Description of Prevention Measure	Feasibility/ Implementation Schedule
	Recycle H_2/N_2 within the reactor and minimize that quantity of gas that is purged to the Flare Gas Header. This practice is currently utilized at the CFHU, JHF, ULSD, HCU, and NRU because these units include recycle gas compressors as an inherent part of the reactor circuit design. Therefore, consideration of this prevention measure only applies to the LCNHF, HCNHF, DHF, VNHF, MRU, and ALKY.	Based on the design of the Benicia Refinery, it is not technically feasible to recycle H_2 at the LCNHF, HCNHF, DHF, VNHF, MRU, and ALKY. These units do not have recycle gas compressors and are not designed for recycle.
	Route the low Btu gases (H_2/N_2) to the Fuel Gas Unit and add natural gas to meet Btu specifications for fuel gas.	The use of natural gas to increase Btu content is not technically feasible because the quantity of natural gas needed would cause a fuel gas imbalance which would still result in flaring.
	Segregate low Btu gases (H_2/N_2) and routine base-load flare gases. Route the low Btu gases to the flare and the routine base-load flare gases to fuel gas recovery.	Based on the design of the Benicia Refinery, it is not technically feasible to segregate the low Btu gases and routine base-load flare gases. Additionally, even if this could be accomplished, flaring would not be reduced because fuel gas needs to be added to the low Btu gases to ensure effective combustion at the flares.

Maintenance Activity and Process Units	Description of Prevention Measure	Feasibility/ Implementation Schedule
	wide shutdowns and subsequent startups.	subsequent startup. The Benicia Refinery is very integrated for energy efficiency and tankage inventory purposes. As a result, when major maintenance is needed at the PS or FGS the remaining process units need to be shutdown. Maintenance activities at units other than the PS and FGS are staggered to minimize flaring.

5.1.4 Benicia Refinery Maintenance Planning and Preparation

In this section the role of planning and preparation is discussed as it relates to flare minimization associated with planned and unplanned maintenance activities including startup, shutdown, and turnaround activities. In recent years, the Benicia Refinery has implemented a flare minimization planning process that has become a part of the refinery's normal operating practice prior to conducting maintenance activities that may cause flaring. This pre-maintenance planning is conducted to identify practices and procedures that may help to minimize flaring. These same practices and procedures are also used to the greatest extent possible in the event of an unplanned maintenance activity. In all cases, it should be emphasized that these procedures and practices are always implemented in a manner that does not compromise the safety of refinery operations, or would present a risk of exposure to refinery personnel or the community.

5.1.4.1 Flare Minimization Planning for Planned Maintenance Activities

For planned maintenance activities at the Benicia Refinery, flare minimization planning is currently being conducted to minimize the frequency and magnitude of flaring associated with planned maintenance. This flare minimization planning process shown in Figure 8 presents the thought process logic that is followed to ensure the potential for flaring is considered before maintenance activities are conducted. Additionally, use of this flare minimization planning process ensures continuous improvement because the process includes (1) consideration of measures to minimize flaring prior to conducting planned maintenance, (2) an evaluation of causes, contributing factors, and/or lessons learned for every significant flaring event, and (3) consideration of measures to minimize future flaring after a flaring event has occurred as a result of maintenance.

After the maintenance activities are conducted, if the flaring event exceeds 0.5 mmscfd or 500 lb/day of SO_2, a formal evaluation of cause and contributing factors is conducted and measures to minimize future flaring are considered. The results of formal evaluations and lessons learned are used during the planning process for future maintenance activities that are similar in nature.

5.1.4.2 Flare Minimization During Unplanned Maintenance and Feed Outages

There are occasions (primarily as a result of equipment malfunction) when a relatively immediate decision is made to shutdown a process unit or block of process units, typically within a period of minutes or hours, allowing very little time for planning. In these cases, it is often not possible to make all the up-front adjustments necessary to minimize flaring to the same extent as is possible when the shutdown is planned in advance. Despite this, actions that can be taken to minimize flaring are implemented to the greatest extent possible. For these cases, the refinery utilizes the same general procedures that have been developed to minimize the frequency and magnitude of flaring during maintenance events, as shown in Figure 8. The flare minimization measures that are considered for planned maintenance (listed above) are also considered for unplanned shutdowns and lessons learned are informally captured for future consideration during similar future events. If flaring events from unplanned shutdowns exceed 0.5 mmscfd or 500 lb/day of SO_2a formal evaluation of cause and contributing factors is conducted and measures to minimize future flaring are considered.

5.2 Prevention Measures – Fuel Gas Quantity and Quality

As discussed in Section 2.2.2, flaring can occur as a result of fuel gas quantity and quality issues if (1) the quantity of fuel gas generated is larger than can be managed by the Flare Gas Compressors, Fuel Gas Unit, and/or fuel gas consumers; or (2) the quality (composition) of fuel gas is such that it must be routed to the flare because it cannot be utilized by the fuel gas consumers. When flaring is caused by fuel gas quantity and quality issues, the general cause of flaring is often maintenance activities, equipment failure and malfunction, emergency situations and/or safety reasons. This section examines potential prevention measure to reduce flaring by reducing fuel gas quantity and quality issues. Specifically, this section examines both the advantages and the feasibility of adding flare gas recovery capacity.

All prevention measures that are considered in this section for fuel gas quantity and quality are focused on reducing flaring loads at the South and North Flares. Any reduced flaring associated with a particular prevention measure will result in decreased emissions of all pollutants including sulfur dioxide (SO_2) and will also result in increased treatment and recovery of sulfur containing gases. To decrease SO_2 emissions and increase treatment and recovery of sulfur containing gases, flare gas must be diverted from the flares and sent to the Fuel Gas Unit where the sulfur compounds are treated in the Fuel Gas Treatment Scrubber (T-1201). This scrubber has a maximum capacity of about 70 mmscfd of sour fuel gas and receives an average of about 50 mmscfd of sour fuel gas. The Fuel Gas Treatment Scrubber is sufficiently sized to accommodate recovered flare gas that is diverted from the flares (the 50 mmscfd average sour fuel gas flow to T-1201 includes an average of about 5 mmscfd of recovered flare gas). Additional Fuel Gas Treatment Scrubbing capacity will not reduce flaring or SO_2 emissions. Therefore, the only way to decrease SO_2 emissions is to reduce flaring.

Flaring at the Acid Gas Flare is not caused by issues of gas quantity and quality (i.e. a larger recovery and treatment system will not reduce flaring because the Acid Gas Flare does not utilize a recovery and treatment system). A recovery and treatment system for the Acid Gas Flare is not practical for several reasons. First, acid gas does not have a heating value (i.e., there are little or no hydrocarbons in acid gas), so there is no use for recovered acid gas as fuel gas. Additionally, use of the Acid Gas Flare is very limited and is primarily used for emergency and upset situations so there is normally no flow in the Acid Gas Flare Line. As such, treatment and recovery are not practical because scrubbers cannot handle flow rates between zero and the design flow rate of the Acid Gas Flare, as well as the high concentration of H_2S in the acid gas during emergencies and upsets. Finally, even if recovery and treatment were possible, it would not be warranted because utilization of the Acid Gas Flare and the resulting emissions are too small. Emergency and upset events provide the only potential for Acid Gas Flare events in excess of 0.5 mmscfd or 500 lb/day of SO_2.

5.2.1 Existing Flare Gas Recovery Capacity at Benicia Refinery

In this section the capacity of that system is reviewed in further detail, and considered in light of flaring event information from 2017 Options for possible expansion of the system

The total fuel gas scrubbing capacity that is indicated is an integral part of the refinery fuel gas management system. This capacity is closely matched with the fuel gas consumers' (furnaces, boilers, gas turbines, and COGEN) usage requirements. The capacity indicated as being available for recovered flare gas scrubbing will vary depending on the balance between fuel gas production and consumption; it will vary both on a seasonal basis and during the course of the day.

With this system for flare gas recovery in place, the Benicia Refinery has recovered a daily average flow of 3.0 mmscfd during the 2017 calendar year. Total gases flared during that time period were an average of 0.25mmscfd, demonstrating that the Flare Gas Recovery System effectively recovered and reused greater than 92 percent of the gases routed to the flare gas header(s) in 2017. On an annual basis, out of 2,400 mmscf total volume measured in the flare gas header, 2,200mmscf were recovered.

5.2.2 Evaluation of Options for Additional Flare Gas Recovery, Scrubbing and Use

To address the requirements of Regulation 12-12-401.4, the Benicia Refinery has considered the feasibility of further reducing flaring through additional recovery, scrubbing, and/or storage of Flare Gas Header gases, or to use the recovered gases through other means. This evaluation considers the impact these additional systems would have on the volume of flared gases remaining in excess of what has already been recovered (as noted in the previous section), and the associated mass flow of hydrocarbons emitted after combustion in the flare control device.

5.2.2.1 Typical Flare Gas Recovery System Components

A typical Flare Gas Header is connected to both a flare gas recovery system and to one or more flares. Normally all vapor flow to the Flare Gas Header is recovered by a Flare Gas Compressor, which increases the pressure of the flare gas allowing it to be routed to a fuel gas treatment scrubber for removal of contaminants such as sulfur and then to the refinery fuel gas consumers. Gas in excess of what can be handled by the Flare Gas Compressor(s), the treatment scrubber(s), and/or the fuel gas consumers flows to a refinery flare so it can be safely disposed of by combustion. Therefore, in order to reduce the volume of gas flared, three essential infrastructure elements are required: (1) sufficient compressor capacity to increase the pressure of the gas to the point where it can be used in the refinery fuel system; (2) sufficient storage volume to dampen out the variation in volumetric flow rate to the flare gas header; and (3) sufficient capacity of treatment scrubber systems to condition the gas (primarily by removal of sulfur) for use as fuel gas.

Figure 9 shows the configuration of a typical flare gas recovery system and its components.

Options for storage of flare gas are analogous to those for storage of other refinery gases such as propane and butane. Gases can be stored at low pressure in expandable gas-holders with either liquid (water) or dry (fabric diaphragm) seals. The volumes of these systems expand and contract as gas is added or removed from the container. Very large vessels, containing up to 10 mmscf of gas can be constructed by using multiple "lifts," or stages. Gases can also be stored at higher pressures, and correspondingly lower volumes, in steel bullets or spheres, but a compressor would be required to capture the excess flare gas. The optimal pressure vessel configuration depends on system design pressure and total required storage volume.

For any type of gas storage facility, selection of an acceptable site and obtaining the permits necessary for construction both present difficulties. Despite a refinery's demonstrated commitment and strong track record with respect to safe handling of hazardous materials, the surrounding community can be expected to have concerns about any plan to store large volumes of flammable gas containing hydrogen sulfide and other sulfur compounds. Safety concerns are expected to impact site selection as well, with a relatively remote location preferred. Modifications to the recovery, storage, and treatment scrubbing of recovered refinery fuel gases are subject to the provisions and approval of federal and local regulations including Process Safety Management (PSM) and California Accidental Release Prevention Program (CalARP). Although the objective of the project would be a reduction in flaring, there are expected to be multiple hurdles along the path to a construction/land use permit.

Fuel gas treatment scrubbers are used to condition flare gas prior to combustion as fuel at furnaces, boilers, gas turbines and COGEN. Treatment scrubbing is focused on removal of sulfur compounds, with some systems improving fuel value by removing carbon dioxide as well. A range of technology options exist, most of which are based on absorption of acid gases into a "lean" amine solution with regeneration of the resulting "rich" solution by stripping at lower pressure. In order to recover additional fuel gas, it is necessary to have sufficient capacity to match the capacity of gas treating systems to the peak flow rate of the flare gas requiring treatment.

5.2.2.2 Feasibility of Expanding the Existing Flare Gas Recovery System

In order to assess the potential effect of additional flare gas recovery, a hypothetical design for an upgraded system was developed. The impact that this system would be expected to have on non-methane hydrocarbon (NMHC) emissions and other pollutants have been evaluated based on the refinery's flaring history from 2005. Results of this evaluation are provided for three system sizes. The budgetary level (order of magnitude) cost information provided in this section has been developed based on total installed cost data from similar installations where available, in combination with equipment vendor quotes and standard industry cost estimation procedures. Figure 10 shows the configuration of a typical flare gas recovery system, modified to increase its recovery capacity as discussed below.

recovery to allow flare gas flow (which is highly variable) to be matched to the demand for fuel gas. The cost used is based on a storage volume equal to the total volume of gas accumulated over one day at the identified flow rate, and is based on recovery in a high pressure sphere system with discharge at a controlled rate back to the flare gas header. Other lower pressure approaches were considered (low pressure gas holder, medium pressure sphere), but for the sizes analyzed a high pressure sphere was identified as the preferred approach based on operational, safety and economic considerations. For the large storage volumes needed for some of the options considered, the cost is based on the use of multiple spheres.

Additional recovered fuel gas treatment scrubbing capacity – the cost of additional amine-based treating capacity to process recovered gases for sulfur removal so that they can be burned by existing fuel gas consumers without exceeding environmental or equipment operational limits. Installed cost data for new fuel gas treatment scrubbing systems were scaled to estimate the cost of adding scrubbing capacity for each of the evaluated flow rates. The assumption is that for small increases in scrubbing capacity the existing treatment scrubber would be modified or upgraded to allow for the increase. No additional cost has been included for expansion of the sulfur recovery system (SGU and TGU), although in actual fact it could be required.

Table 5-4 provides a summary of the estimated cost for the three flare gas recovery system components described above.

Table 5-4 – Summary of Estimated Cost for Flare Gas Recovery System Expansion

Additional Capacity	Additional Fuel Compressor Capacity	New Surge Storage Capacity (1)	Additional Scrubber Capacity	Entire System(2)
2 mmscfd	\$3,600,000	\$5,000,000	\$2,000,000	\$10,600,000
6 mmscfd	\$7,800,000	\$15,000,000	\$4,700,000	\$27,500,000
24 mmscfd	\$31,200,000	\$60,000,000	\$6,000,000	\$97,200,000

(1) 24 hours of storage of the specified flow rate.

(2) 2006 cost basis. Values need not be updated for subsequent years because the cost will always increase.

To provide a more complete understanding of the potential impact of providing an expanded Flare Gas Recovery System, the following additional evaluation has been performed:

option is necessary if the improvements in flare gas recovery shown are to be realized.

In order to capture the gas associated with the type of longer duration flaring event that accounts for most emissions from the flares on an annual average basis, a very large capacity for flare gas compression and storage is needed. The third case presented, for a system with a capacity of 24 mmscfd, reflects what would be needed for control for this type of event. The system as proposed makes use of 6 flare gas compression systems at 4 mmscfd, each feeding one of 24 60-foot diameter storage spheres. The increase in treatment capacity is limited to 8 mmscfd, as flare gas would be stored prior to treatment and worked off through a treater at a gradual rate in line with the ability of the Fuel Gas Unit to accept it.

Based on this review the Benicia Refinery has concluded that further expansion of systems for the recovery, treatment and use of flared gases is not the most feasible and cost-effective approach to reducing these emissions. The Benicia Refinery has concluded that the major source of flared gases on a volume basis can be attributed to large flow rate flaring events, especially those of extended duration such as may occur during emergency events or prolonged shutdowns where systems within the refinery are out of fuel gas (and/or hydrogen) balance.

An evaluation of the cost-effectiveness of reducing emissions through a major Flare Gas Recovery System expansion is summarized in Table 5-5 based on the evaluations presented above for NMHC emissions. The capital cost investment has been converted to an annual basis based on BAAQMD guidelines for calculation of cost-effectiveness for Best Available Control Technology (BACT).

Table 5-5 – Summary of Estimated Cost Effectiveness for Flare Gas Recovery System Expansion Based on NMHC Emissions (2006 cost basis, actual cost in subsequent years is always greater and not necessary to recalculate)

Additional Capacity (mmscfd)	System Expansion Estimated Cost	Annualized Cost per BAAQMD Guidelines	Estimated Emissions Reduction, tpy	Estimated Cost Effectiveness, $/ton
2	$10,600,000	$2,700,000	13.7	$200,000
6	$27,500,000	$7,050,000	24.5	$300,000
24	$97,200,000	$25,050,000	29.9	$800,000

Table 5-5 shows that each of these approaches is not cost-effective. Similarly, Table 5-6 shows that these approaches are even less cost-effective for emissions of SO_2, NO_X, CO and PM10. In fact, these approaches are more than an order of magnitude less cost-effective than the typical thresholds used by the BAAQMD. Rather than

Benicia Refinery has developed and implemented a preventative maintenance program that minimizes the chance of recurrent failure.

5.3.1 Benicia Refinery Preventative Maintenance

The preventive maintenance program at the Benicia Refinery is a key component of the refinery's flare minimization process. The Benicia Refinery has a progressive preventative maintenance program which reduces the frequency and magnitude of equipment failures and malfunctions that can cause unplanned shutdown events that often result in flaring. There are both environmental and financial incentives for a thorough preventative maintenance program because unplanned shutdowns typically result in both production losses and flaring.

In 2004-2005, the refinery conducted a third-party, site-wide reliability assessment to identify opportunities for equipment reliability improvements. This study not only looked at the reliability of rotating and other mechanical equipment, but also assessed technical issues such as rates of corrosion and the preferred metallurgy of key system components throughout the facility.

The results of this review revealed that the reliability of the refinery's rotating equipment and compressors is, in general, excellent. For critical un-spared rotating equipment, which can be a cause of gas flow to the Flare Gas Header if an unplanned shutdown occurs, the review showed that the refinery strives for and achieves high operating reliability. This program is closely aligned with the flare minimization process. Quarterly indicators are tracked to ensure this excellent reliability is maintained and improved when opportunities are identified.

The equipment maintenance program has been implemented with the assistance of a third-party expert, Becht Engineering, with recognized expertise in equipment reliability and maintenance systems. Becht Engineering assisted in the development and implementation of written protocols and procedures. In addition to mechanical and rotating equipment, the plant's philosophy for reliability and maintenance excellence also includes other support systems, such as electrical, instrumentation, and process control systems and components.

5.3.2 Recurrent Failure

As defined by Regulation 12-12-401.4.3, a failure is considered to be recurrent if it occurs more than twice during any five year period as the result of the same cause. Over the past five years, there has been no reportable flaring events (i.e., greater than 0.5 mmscfd) at the Benicia Refinery as a result of a recurrent failure, malfunction, or upset. The preventative maintenance program described in the previous section is designed to minimize the chances of repeat failures, malfunctions, and upsets. However, if a failure, malfunction or upset does occur at the Benicia Refinery, a concerted effort is made to reduce the likelihood of a repeat event with the same cause. If repeat failures are sufficiently minimized, "recurrent" failures become unlikely.

fuel gas imbalance unless the imbalance can be anticipated in advance. The extent to which the FCCU and CKR unit adjustments and production cuts can be made is also limited. Specified operating ranges and minimum production rates are required to maintain stable operation and avoid significant flaring that would be caused by unstable operation (or complete shutdown) of the FCCU or CKR including upstream and downstream process units.

Process unit adjustments and production cuts at process units other than the FCCU and CKR are also used to minimize or eliminate flaring. During unit startup, when off-spec products are produced, the unit's reduced production rates minimize the quantity of off-spec products that are sent to the Flare Gas Header. Additionally, during major equipment failure or malfunction, unit adjustments and production cuts at multiple refinery units are often needed to stabilize refinery operations and minimize flaring.

Unit adjustments and production rate cuts have no impact on certain flaring events. For example, these approaches will not reduce flaring caused by fuel gas quality issues, such as high nitrogen and hydrogen, when the gases in the Flare Gas Header are flared instead of being compressed and sent to the Fuel Gas Unit.

HCU	Hydrocracker Unit
HPFG	High Pressure Fuel Gas
HPTG	High Pressure Tail Gas
ID	Inside diameter
JHF	Jet Hydrofining Unit (Hydrotreating; located at PS)
KO	Knockout
lb/day	Pounds per day
LCO	Light Cycle Oil
LCNHF	Light Cat Naphtha Hydrofining Unit (Hydrotreating; located at MRU)
LPFG	Low Pressure Fuel Gas
LPTG	Low Pressure Tail Gas
MMBtu/hr	Million British Thermal Units Per Hour
mmscfd	Million Standard Cubic Feet Per Day
MRU	Motor Gasoline Reformulation Unit (Clean Fuels Unit)
MTBE	MTBE Unit (this unit is shutdown, but a portion of the unit is used by ALKY)
N_2	Nitrogen
NMHC	Non-methane Hydrocarbons
NO_X	Nitrogen Oxides
NSPS	New Source Performance Standards
NRU	Catalytic Naphtha Reforming Unit
OMS	Oil Movements (Tank Farms and Blending)
P&ID	Process and Instrumentation Diagram
PM10	Respirable Particulate Matter (< 10 micron diameter)
PRDs	Pressure Relief Devices
PS	Pipestill (Crude Unit)
psig	Pounds Per Square Inch, Gauge
scf	Standard Cubic Feet
scfm	Standard Cubic Feet Per Minute
SGU	Sulfur Gas Unit (Sulfur Recovery Unit)
SO_2	Sulfur Dioxide
TGU	Tail Gas Unit (SGU Tail Gas/Flexsorb Unit)

Appendix B

The following drawings are included in this appendix:

36-000-03E-73503 – Refinery Flare Gas Recovery System

36-000-03E-73504 – Acid Gas Flare

Appendix B of this FMP contains refinery confidential information and are trade secrets and confidential business information (CBI) of Valero Refining Company – California (Valero) as defined by the California Public Records Act, Government Code Section 6254.7 et seq., and the Freedom of Information Act, 40 CFR Part 2 (40 CFR §2.105(a)(4)), 5 USC 552(b)(4), and 18 USC 1905. Because of the sensitive and competitive nature of the information, Valero requests that the BAAQMD afford the information CBI status and treatment indefinitely. The content of Appendix B in the public version of this FMP has been redacted. A complete copy of the FMP, including Appendix B, is included in the CBI version of the FMP provided to the BAAQMD.

44-000-03D-30869 MRU Blowdown Drum, Slop Oil Pumpout Pumps & Blowdown Cooler (D-2130 Liquid KO Drum)

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