BAY AREA
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APPENDIX D

Emissions and Cost Information

Emissions and Cost Information for Proposed Amendments to Regulation 8: Organic Compounds, Rule 18: Equipment Leaks

This appendix provides emissions and cost information related to the proposed amendments to Regulation 8: Organic Compounds, Rule 18: Equipment Leaks (Rule 8-18).

Current Emission Estimates and Emission Reductions for the Five Refineries

Basis:

- The total component counts for the five refineries were obtained from the Heavy Liquids Study Report. (BAAQMD, 2022)
- The precursor organic compound (POC) emission factors for valves and non-steam quenched pumps were derived from emission data and initial boiling point of materials as reported by the respective refineries as part of the Heavy Liquids Study (BAAQMD, 2022). The POC emission factor is for valves and non-steam quenched pumps handling material with an initial boiling point greater than 302 ºF and less than or equal to 372 ºF.
- The POC emission factor for steam quenched pumps was obtained from Table VI-1a of CAPCOA Report (CAPCOA, 1999). The POC emission factor is for steam quenched pumps handling material with an initial boiling point greater than 302 ºF. Emission factors from the Heavy Liquids Study Report were not available for this component type. Staff determined the emission factors used in this analysis represent the best available and most appropriate data based on a review of available published data, studies, and emission factors.
- The POC emission factor for pressure relief device was obtained from Table 4-2 of EPA Report (U.S. EPA, 1979). Emission factors from the Heavy Liquids Study Report were not available for this component type. Staff determined the emission factors used in this analysis represent the best available and most appropriate data based on a review of available published data, studies, and emission factors.
- Details on calculations for controlled emissions are described below in the section on "Controlled Emission Factors"
- Current total organic compound (TOC) emissions and controlled TOC emissions were estimated using POC emission factors, as TOC emission factors were not available.

Table 1 – Emissions and Emission Reductions for Affected Components in Heavy Liquid Service at the Five Refineries

Component Type	Total Component Counts	POC Emission Factor (lb/hour-component)	Current TOC Emissions (tons/year)	Controlled - POC Emission Factor (lb/hour-component)	Controlled TOC Emissions (tons/year)	TOC Emission Reduction (tons/year)
Valves	15,629	8.47E-05	5.8	2.79E-05	1.9	3.9
Non-Steam Quenched Pumps	203	9.21E-04	0.8	7.20E-04	0.6	0.2
Steam Quenched Pumps	381	4.63E-02	77.3	7.20E-04	1.2	76.1
Pressure Relief Valves	600	1.90E-02	49.9	1.31E-04	0.3	49.6
		Total	133.8	--	4.1	129.7

<u>Current Emission Estimates and Potential Emission Reductions for the Seven Non-Refinery Facilities</u>

Basis:

- The component counts for the non-refinery facilities are estimated using facility-specific light liquid service component counts and an assumed heavy liquid-to-light liquid component ratio based on staff's review of historical data available.
- The precursor organic compound (POC) emission factors for valves and non-steam quenched pumps were derived from emission data and initial boiling point of materials as reported by the respective refineries as part of the Heavy Liquids Study (BAAQMD, 2022). The POC emission factor is for valves and non-steam quenched pumps handling material with an initial boiling point greater than 302 ºF and less than or equal to 372 ºF.
- The POC emission factor for steam-quenched pumps was obtained from Table IV-1a of CAPCOA Report (CAPCOA, 1999). Emission factors from the Heavy Liquids Study Report were not available for this component type. Staff determined the emission factors used in this analysis represent the best available and most appropriate data based on a review of available published data, studies, and emission factors.
- The POC emission factor for pressure relief device was obtained from Table 4-2 of EPA Report (U.S. EPA, 1979). Emission factors from the Heavy Liquids Study Report were not available for this component type. Staff determined the emission factors used in this analysis represent the best available and most appropriate data based on a review of available published data, studies, and emission factors.
- Details on calculations for controlled emissions are described below in the section on "<u>Controlled Emission Factors</u>"
- Current TOC emissions and controlled TOC emissions were estimated using POC emission factors, as TOC emission factors were not available.

Table 2 – Emissions and Emission Reductions for Affected Components in Heavy Liquid Service at the Seven Non-Refinery Facilities

Component Type	**Total Component Counts**	**POC Emission Factor** (lb/hour-component)	**Current TOC Emissions** (tons/year)	**Controlled - POC Emission Factor** (lb/hour-component)	**Controlled TOC Emissions** (tons/year)	**TOC Emission Reduction** (tons/year)
Valves	3,253	8.47E-05	1.2	2.79E-05	0.4	0.8
Non-Steam Quenched Pumps	34	9.21E-04	0.14	7.20E-04	0.11	0.03
Pressure Relief Valves	150	1.90E-02	12.5	1.31E-04	0.1	12.4
		Total	13.8	--	0.6	13.2

<u>Controlled Emission Factors</u>

Basis:

- Controlled POC emission factors were derived using the correlation equation below from CAPCOA Report (CAPCOA, 1999). The correlation equation is provided in Equation 1.

$$\mathbf{Emissions}_{\mathbf{Type}} = \left(\mathbf{M}_{\mathbf{Type}}\right) \times (\mathbf{SV})^{\mathbf{Power}_{\mathbf{Type}}} \qquad \text{[Equation 1]}$$

where:

$Emissions_{Type}$ = hourly emissions from a single component
M_{Type} = component type-specific multiplier (see Table 3)
SV = screening value (parts per million by volume, ppmv)
$Power_{Type}$ = component type-specific power (see Table 3)

- Staff assumed a screening value of 10 ppmv for valves and a screening value of 20 ppmv for steam-quenched pumps, non-steam quenched pumps, and pressure relief devices based on staff's review of historical LDAR screening data for light liquid components.

Table 3 - Default Zero Factors and Correlation Equations for Monitored Fugitive Emissions

Component Type / Service Type	**Default Zero Factor** (1), (2) (kg/hour)	**Correlation Equation** (1), (3) (kg/hour)	
		$\mathbf{M}_{\mathbf{Type}}$	$\mathbf{Power}_{\mathbf{Type}}$
Valves / All	7.8E-06	2.27E-06	0.747
Pump Seals / All	1.9E-05	5.07E-05	0.622
Connectors	7.5E-06	1.53E-06	0.736
Pressure Relief Valves / All	4.0E-06	8.69E-06	0.642

1. Table IV-3a of "California Implementation Guidelines for Estimating Mass Emissions of Fugitive Hydrocarbon Leaks at Petroleum Facilities", CAPCOA. February 1999.
2. The default zero factors only apply when the screening value, corrected for background, equals 0.0 ppmv.
3. The correlation equations can only be used when the screening background, corrected for background, equals 9,999 ppmv or less.

Compliance Cost Calculations

Monitoring Costs

Basis:

- Inspection cost rate (per inspection) was estimated based on inspection cost information published in previous Air District rulemaking analyses (BAAQMD, 1997) with adjustments for inflation to 2023 dollars based on the Chemical Engineering Plant Cost Index (CEPCI). Staff also reviewed other inspection cost data from South Coast AQMD Rule 1173 rulemakings (SCAQMD, 2002, 2007, 2009) and San Joaquin Valley Unified APCD rulemakings (SJVUAPCD, 2023); this other inspection cost data did not indicate substantially different costs than the estimates developed by staff.
- A leak component fraction of 1.5% was assumed based on the Heavy Liquids Study Report. (BAAQMD, 2022)
- Hourly labor rate and component replacement costs were based on Table C-4 of Appendix C of SJVUAPCD Staff Report for Proposed Amendments to Rules 4401, 4409, 4455, 4623, and 4624. (SJVUAPCD, 2023)
- Average repair time for valves was based on Table C-4 of Appendix C of SJVUAPCD Staff Report for Proposed Amendments to Rules 4401, 4409, 4455, 4623, and 4624. (SJVUAPCD, 2023)
- Average repair time for pumps and pressure relief devices were based on previous estimates from Air District rulemaking analyses (BAAQMD, 2015).
- For pumps and valves, a range of potential compliance costs were estimated based on alternate inspection schedules for valves and pumps. Maximum cost estimates were developed based on an inspection frequency of quarterly (for pumps) and semiannually (for valves). Minimum cost estimates were developed based on alternate inspection schedules per Section 8-18-404. For alternate inspection schedule scenarios, all components except the leaking component fraction of 1.5% were assumed to be on an annual inspection schedule.
- Pressure relief devices were assumed to be inspected on a quarterly basis.
- For the repair and replacement costs for leaking components, staff assumed that 95% of the leaking components would be repaired and 5% of the remaining components would be replaced. This was based on a review of historical fugitive component repair data, which indicated that a large majority of the leaking components were repaired when components were leaking.
- Total Inspection Cost [$/component per year] =
  (Inspection Cost)*(Inspection Frequency) +
  (Leaking Component Fraction)*(95%)*(Average Repair Time)*(Hourly Labor Rate) +
  (Leaking Component Fraction)*(5%)*(Average Replacement Time)*(Hourly Labor Rate) +
  (Leaking Component Fraction)*(5%)*(Component Replacement Cost)

Table 4 – Inspection, Repair, and Replacement Cost Assumptions

Item	Pump – Alternate Inspection Schedule	Pump - Quarterly Inspection	Valve – Alternate Inspection Schedule	Valves - Semiannual	Pressure Relief Devices - Quarterly	Unit
Inspection Cost	$4.16	$4.16	$4.16	$4.16	$4.16	Per inspection
Leaking Component Fraction	1.5%	1.5%	1.5%	1.5%	1.5%	Percent of total inspected components found leaking
Hourly Labor Rate	$133	$133	$133	$133	$133	Per hour
Average Repair Time	4	4	0.17	0.17	4	Hours per repair
Average Replacement Time	40	40	4	4	40	Hours per replacement
Component Replacement Cost	$166.10	$166.10	$150.00	$150.00	$221.40	
Inspection Frequency	1.045	4	1.015	2	4	Average inspections per component per year
Total Inspection Cost	$16.04	$28.32	$5.05	$9.15	$28.36	Per component per year

Component Identification Costs

Basis:

- Tagging time, cost of tags, electronic inventory time, and data entry labor cost were based on previous estimates from Air District rulemaking analyses (BAAQMD, 2015).
- Cost of tag and data entry labor cost was adjusted for inflation based on Chemical Engineering Plant Cost Index to adjust estimates to 2023 dollars.
- Total Identification Cost [$/component] =
((Electronic Inventory Time/60) + (Tagging Time/60))*(Data Entry Labor Cost) +
(Cost of Tag)

Table 5 – Identification Cost Assumptions

Item	Value	Unit
Tagging Time	5	minutes per component
Cost of Tag	$4.06	per tag
Electronic Inventory Time	0.25	minutes per component
Data Entry Labor Cost	$40.61	per hour
Total Identification Cost	$7.61	per component

- These one-time component identification costs were amortized with an estimated Capital Recovery Factor (CRF) using the assumptions shown below.

Table 6 – Amortization Cost Assumptions

Total Annual Costs	Capital Recovery Factor	Description
Amortization/Capital Recovery	0.136	CRF based on lifetime of 10 years, interest rate of 6%
Tax	0.01	Default factor per Cost Effectiveness BACT Policy and Implementation Procedure
Insurance	0.01	Default factor per Cost Effectiveness BACT Policy and Implementation Procedure
G&A (General & Administrative)	0.02	Default factor per Cost Effectiveness BACT Policy and Implementation Procedure
O&M (Operating and Maintenance)	0.1	Operating and maintenance cost factor based on EPA Control Cost Manual
Total	**0.28**	

Estimated Total Annual Compliance Cost by Component Type

- Total annualized compliance costs were calculated by component type for refinery and non-refinery facilities using the monitoring costs, identification costs, and component data described previously.

Table 7 – Estimated Total Annual Compliance Cost by Component Type for the Five Refineries

Component Type	**Identification Costs** ($) - One Time Cost	**Identification Costs- Amortized** ($/year)	**Min. Monitoring Costs** ($/year)	**Max. Monitoring Costs** ($/year)	**Min. Total Compliance Cost** ($/year)	**Max. Total Compliance Cost** ($/year)
Valves	$118,995	$32,827	$78,963	$142,947	$111,790	$175,774
Non-Steam Quenched Pump Seals	$1,546	$426	$3,256	$5,749	$3,682	$6,175
Steam Quenched Pumps	$2,901	$800	$6,111	$10,790	$6,911	$11,590
Pressure Relief Valves	$4,568	$1,260	$17,017	$17,017	$18,278	$18,278
Total	$128,010	$35,314	$105,347	$176,503	$140,660	$211,817

Table 8 - Estimated Total Annual Compliance Cost by Component Type for the Seven Non-Refinery Facilities

Component Type	**Identification Costs** ($) - One Time Costs	**Identification Costs- Amortized** ($/year)	**Min. Monitoring Costs** ($/year)	**Max. Monitoring Costs** ($/year)	**Min. Compliance Cost** ($/year)	**Max. Compliance Cost** ($/year)
Valves	$24,768	$6,833	$16,435	$29,753	$23,268	$36,585
Non-Steam Quenched Pump Seals	$259	$71	$545	$963	$617	$1,034
Pressure Relief Valves	$1,142	$315	$4,254	$4,254	$4,569	$4,569
Total	$26,168	$7,219	$21,235	$34,970	$28,454	$42,189

<u>Estimated Total Cost Effectiveness by Component Types</u>

- Cost effectiveness is calculated by dividing the annualized compliance costs by the total number of tons of emission reductions expected each year.
- Cost effectiveness was calculated by component type for refinery and non-refinery facilities using the emission reduction and compliance cost estimates described previously.

Table 9 - Estimated Cost Effectiveness by Component Type for the Five Refineries

Component Type	**TOC Emission Reduction** (tons/year)	**Min. Compliance Cost** ($/year)	**Max. Compliance Cost** ($/year)	**Min. Cost Effectiveness** ($/ton of emissions reduced)	**Max. Cost Effectiveness** ($/ton of emissions reduced)
Valves	3.9	$111,790	$175,774	$28,766	$45,230
Non-Steam Quenched Pumps	0.2	$3,682	$6,175	$20,664	$34,656
Steam Quenched Pumps	76.1	$6,911	$11,590	$91	$152
Pressure Relief Valves	49.6	$18,278	$18,278	$369	$369
Total	129.7	$140,660	$211,817	-	-

Table 10 - Estimated Cost Effectiveness by Component Type for the Seven Non-Refinery Facilities

Component Type	**TOC Emission Reduction** (tons/year)	**Min. Compliance Cost** ($/year)	**Max. Compliance Cost** ($/year)	**Min. Cost Effectiveness** ($/ton of emissions reduced)	**Max. Cost Effectiveness** ($/ton of emissions reduced)
Valves	0.8	$23,268	$36,585	$28,766	$45,230
Non-Steam Quenched Pumps	0.03	$617	$1,034	$20,664	$34,656
Pressure Relief Valves	12.4	$4,569	$4,569	$369	$369
Total	13.2	$28,454	$42,189	-	-

Incremental Cost Effectiveness Analysis

Emission Reductions Under Alternative Control Scenario

Basis:

- Incremental cost effectiveness is calculated by 1) calculating the incremental difference in cost between the different regulatory options, and 2) dividing the incremental difference in cost by the incremental difference in emission reductions between each progressively more stringent regulation.
- For valves and non-steam quenched pumps, an alternative control scenario may involve expanding LDAR requirements to all valves and pumps in heavy liquid service handling material with an initial boiling point greater than 302 ºF (including those handling material with an initial boiling point greater than 372 ºF).
- The total component counts for the five refineries were obtained from the Heavy Liquids Study Report. (BAAQMD, 2022)
- The POC emission factors for valves and non-steam quenched pumps were derived from emission factor from the Heavy Liquids Study report and the data of initial boiling points of materials within the Heavy Liquids Study.
- Controlled emissions for valves and non-steam quenched pumps handling material with an initial boiling point greater than 302 ºF was estimated by applying the percent emissions reductions for valves and non-steam quenched pumps handling material with an initial boiling point greater than 302 ºF and less than or equal to 372 ºF to the current emission estimate for the affected components under this alternative control scenario.

Table 11 - Emission Reductions for Valves and Non-Steam Quenched Pumps Handling Material with an Initial Boiling Point Greater than 302 ºF (Alternative Control Scenario)

Component Type	**Component Counts**	**POC Emission Factor** (lb/hour-component)	**Current TOC Emissions** (tons/year)	**Controlled TOC Emissions** (tons/year)	**TOC Emission Reduction** (tons/year)
Valves	52,595	4.04E-05	9.3	3.1	6.2
Non-Steam Quenched Pumps	1,123	2.27E-04	1.1	0.9	0.2
		Total	10.4	3.9	6.5

Compliance Costs Under Alternative Control Scenario

- Total annualized compliance costs were calculated by component type using the monitoring costs, identification costs, and component data described previously.

Table 12 - Estimated Total Annual Compliance Cost for Valves and Non-Steam Quenched Pumps Handling Material with an Initial Boiling Point Greater than 302 ºF (Alternative Control Scenario)

Component Type	**Identification Costs** ($) - One Time Costs	**Identification Costs- Amortized** ($/year)	**Min. Monitoring Costs** ($/year)	**Max. Monitoring Costs** ($/year)	**Min. Total Compliance Cost** ($/year)	**Max. Total Compliance Cost** ($/year)
Valves	$400,445	$110,470	$265,726	$481,047	$376,196	$591,517
Non-Steam Quenched Pumps	$8,550	$2,359	$18,012	$31,804	$20,370	$34,163
Total	$408,995	$112,829	$283,738	$512,851	$396,567	$625,679

Cost Effectiveness and Incremental Cost Effectiveness Under Alternative Control Scenario

- Cost effectiveness was calculated by component type using the emission reduction and compliance cost estimates described previously.
- Incremental cost effectiveness was calculated for the Alternative Control Scenario (compared to the proposed amendments) using the emission reductions and compliance cost estimates described previously for both scenarios.

Table 13 - Estimated Cost-Effectiveness for Valves and Non-Steam Quenched Pumps Handling Material with an Initial Boiling Point Greater than 302 ºF (Alternative Control Scenario)

Component Type	**TOC Emission Reduction** (tons/year)	**Min. Compliance Cost** ($/year)	**Max. Compliance Cost** ($/year)	**Min. Cost-Effectiveness** ($/ton of emissions reduced)	**Max. Cost-Effectiveness** ($/ton of emissions reduced)
Valves	6.2	$376,196	$591,517	$60,367	$94,919
Non-Steam Quenched Pumps	0.2	$20,370	$34,163	$83,701	$140,373
Total	6.5	$396,567	$625,679	-	-

Table 14 - Estimated Incremental Cost-Effectiveness for Valves and Non-Steam Quenched Pumps under Proposed Amendments and Alternative Control Scenario

Component Type	**Proposed Amendments: Components Handling Material - 302 ºF < IBP ≤ 372 ºF**		**Alternative Control Scenario: Components Handling Material - 302 ºF < IBP**		**Incremental Cost-Effectiveness** ($/ton)
	TOC Emission Reduction (tons/year)	**Compliance Cost** ($/year)	**TOC Emission Reduction** (tons/year)	**Compliance Cost** ($/year)	
Valves	3.9	$111,790 - $175,774	6.2	$376,196 - $591,517	$112,725 - $177,244
Non-Steam Quenched Pumps	0.18	$3,682 - $6,175	0.24	$20,370 - $34,163	$256,043 - $429,405