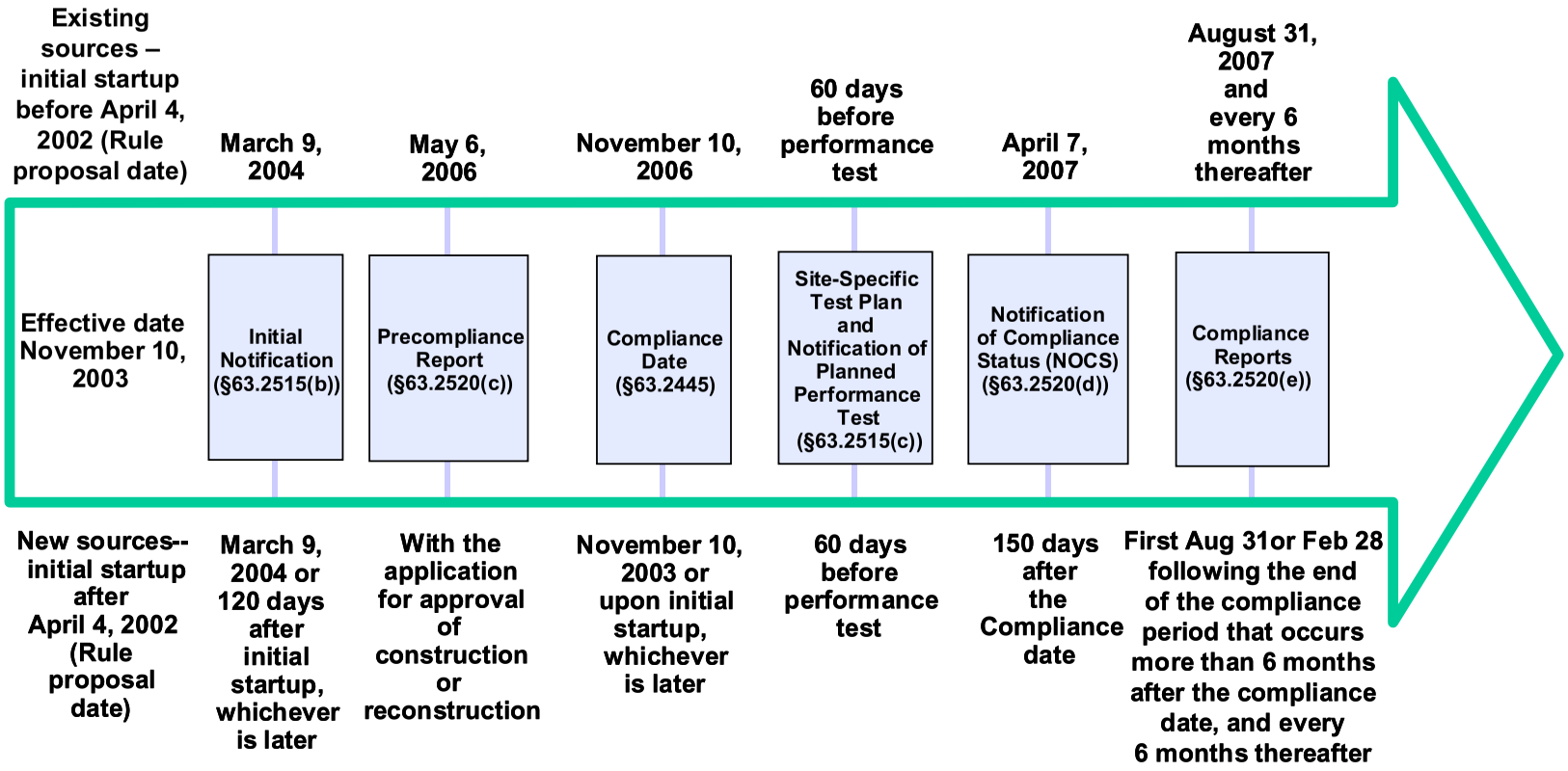
Appendix A

- Compliance Timeline

[This page intentionally left blank.]


Existing sources – initial startup before April 4, 2002 (Rule proposal date)
March 9, 2004
May 6, 2006
November 10, 2006
60 days before performance test
April 7, 2007
August 31, 2007 and every 6 months thereafter
Effective date November 10, 2003
Initial Notification (§63.2515(b))
Precompliance Report (§63.2520(c))
Compliance Date (§63.2445)
Site-Specific Test Plan and Notification of Planned Performance Test (§63.2515(c))
Notification of Compliance Status (NOCS) (§63.2520(d))
Compliance Reports (§63.2520(e))
New sources-- initial startup after April 4, 2002 (Rule proposal date)
March 9, 2004 or 120 days after initial startup, whichever is later
With the application for approval of construction or reconstruction
November 10, 2003 or upon initial startup, whichever is later
60 days before performance test
150 days after the Compliance date
First Aug 31or Feb 28 following the end of the compliance period that occurs more than 6 months after the compliance date, and every 6 months thereafter

[This page intentionally left blank.]

Appendix B

- Tabular Summaries of Emission Standards and Monitoring Parameters for Subpart FFFF

- Tables Comparing Requirements in Subparts GGG, MMM, and FFFF

[This page intentionally left blank.]

Table 1. Standards for Process Vents

For each ...	And ...	The control options[a] are ...
Group 1 continuous process vent[b]	N/A	• Use any control device or combination of devices (except a flare) that reduces organic HAP by ≥98 percent, or • Use any control device or combination of devices (except a flare) that reduces organic HAP to ≤20 ppmv as organic HAP or TOC, or • Use a flare, or • Use a recovery device to maintain TRE >1.9 at an existing source or >5.0 at a new source

	For each halogenated vent stream[c] that is controlled using a combustion device	• Use a halogen reduction device after the combustion device to reduce hydrogen halide and halogen HAP[d]:
		  • By ≥99 percent by weight, or
		  • To ≤0.45 kg/hr, or
		  • To ≤20 ppmv, or
		• Use a halogen reduction device before the combustion device to reduce the halogen atom mass emission rate to:
		  • ≤0.45 kg/hr, or
		  • ≤20 ppmv

Group 2 continuous process vent	The TRE is ≤5.0 at an existing source or ≤8.0 at a new source	Monitor control device parameters as specified in §63.993 of subpart SS
	The TRE is >5.0 at an existing source of >8.0 at a new source	None
Process with Group 1 batch process vents[e]	N/A	• Use any control device or combination of control devices that reduces organic HAP by ≥98 percent, or • Use any recovery device or combination of recovery devices that reduces organic HAP by ≥95 percent, or • For any subset of vents in the process, use a flare or use any combination of control devices to reduce organic HAP to ≤20 ppmv as total organic HAP or TOC, and reduce collective emissions from other vents in the process by ≥98 percent using control devices or ≥95 percent using recovery devices

Table 1. Standards for Process Vents (continued)

For each ...	And ...	The control options[a] are ...

Process with Group 1 batch process vents[e] (continued)	For collective halogenated vent streams that are controlled using a combustion device	• Use a halogen reduction device after the combustion device to reduce overall hydrogen halide and halogen HAP:
		  • By ≥99 percent by weight, or
		  • To ≤0.45 kg/hr, or
		  • To ≤20 ppmv, or
		• Use a halogen reduction device before the combustion device to reduce the overall halogen atom mass emission rate to
		  • ≤0.45 kg/hr, or
		  • ≤20 ppmv

Process with Group 2 batch process vents	N/A	None

Process with uncontrolled hydrogen halide and halogen HAP emissions from process vents ≥1,000 lb/yr	N/A	• Use a control device or combination of control devices to reduce collective hydrogen halide and halogen HAP:
		  • By ≥99 percent by weight, or
		  • To ≤20 ppmv

Process at a new source with uncontrolled PM HAP emissions from process vents ≥400 lb/yr	N/A	Reduce overall PM HAP emissions by ≥97 percent

[a] Each control option also includes requirements for closed-vent systems (as specified in §63.983), except for the recovery device option for continuous process vents.

[b] A Group 1 continuous process vent means a continuous process vent with a TRE ≤1.9 at an existing source and ≤5.0 at a new source.

[c] A halogenated vent stream means a vent stream determined to have a mass emission rate of halogen atoms contained in organic compounds of ≥0.45 kg/hr.

[d] Hydrogen halide and halogen HAP means hydrogen chloride, hydrogen fluoride, and chlorine.

[e] All of the batch process vents in a process are Group 1 batch process vents if the collective organic HAP emissions from all of the batch process vents are ≥10,000 lb/yr at an existing source or ≥3,000 lb/yr at a new source.

Table 2. Standards for Storage Tanks

For each …	Storing material with a maximum true vapor pressure …	The control options[a] are …
Group 1 storage tank with nonhalogenated vent stream[b,c]	≥76.6 kPa	• Use any combination of control devices (except a flare) that reduces total HAP emissions by ≥95 percent by weight[d], or • Use any combination of control devices (except a flare) that reduces total HAP emissions to ≤20 ppmv as total organic HAP or TOC and ≤20 ppmv of hydrogen halide and halogens,[d,e] or • Use a flare[d], or • Vent to a process or fuel gas system, or • Implement vapor balancing between the storage tank and the rail car or tank truck from which the storage tank is filled
	<76.6 kPa	• Any of the options for a storage tank storing material with a maximum true vapor pressure ≥76.6 kPa, or • Equip the storage tank with either an internal floating roof or an external floating roof

Group 1 storage tank with halogenated vent stream	Of any value	• Any of the options for Group 1 storage tanks with nonhalogenated vent streams, and
		• If the halogenated vent stream is combusted:
		  • Use a halogen reduction device after the combustion device to reduce hydrogen halide and halogen HAP by ≥99 percent by weight, to ≤0.45 kg/hr, or
		  • Use a halogen reduction device before the combustion device to reduce the halogen atom mass emission rate to ≤0.45 kg/hr or to ≤20 ppmv

Group 2 storage tank	N/A	None

[a] Each control option includes requirements for a closed-vent system (as specified in §63.983), except the options to vent to a process or fuel gas system or to use a floating roof.

[b] A Group 1 storage tank means a storage tank with a capacity ≥10,000 gallons storing material with a maximum true vapor pressure ≥6.9 kPa at an existing source or ≥0.69 kPa at a new source.

[c] A halogenated vent stream means a vent stream determined to have a mass emission rate of halogen atoms contained in organic compounds of ≥0.45 kg/hr.

[d] The requirements do not apply during periods of planned routine maintenance of the control device up to 240 hr/yr (360 hr/yr if extension request is approved by Administrator).

[e] Hydrogen halide and halogen HAP means hydrogen chloride, hydrogen fluoride, and chlorine..

Table 3. APCD Monitoring Parameters

APCD	Parameters to Monitor	Section in Subpart SS and Subpart FFFF
Halogen scrubbers	• Continuously monitor scrubber inlet liquid flow, and • Measure or determine inlet gas flow rate, and • Continuously monitor pH or caustic strength of the scrubber effluent	§63.994(c)(1) §63.2450(k)(3)
Absorbers[a]	• Continuously monitor liquid temperature and specific gravity, and • Continuously monitor organic concentration if difference in specific gravities of the saturated scrubbing fluid and the fresh scrubbing fluid is <0.02 specific gravity units	§63.990(c)(1) or §63.993(c)(1)
Condenser[a]	Continuously monitor temperature of condenser outlet (product side)	§63.990(c)(2) or §63.993(c)(2)
Regenerative carbon adsorber[a]	For each regeneration cycle: • Monitor total regeneration stream mass or volumetric flow • Monitor carbon bed temperature after each regeneration and within 15 minutes of the end of each cooling cycle	§63.990(c)(3) or §63.993(c)(3)
Flares	Continuously monitor for presence of pilot flame	§63.987(c)
Thermal incinerator	Continuously monitor temperature immediately downstream of the firebox	§63.988(c)(1)
Catalytic incinerator	• Continuously monitor temperature immediately before and after the catalyst bed, or • Continuously monitor temperature before the bed and check catalyst activity annually	§63.988(c)(2) or §63.2450(k)(4)
Process heaters and boilers where vent gases are not introduced with the primary fuel or the design heat input capacity is not ≥44 MW	Continuously monitor temperature of gases exiting the combustion chamber	§63.988(c)(3)
Other devices	Request approval of planned monitoring	§63.995(c)

[a] The specified parameters also apply if the absorber, condenser, or regenerative carbon adsorber is used as a final recovery device for continuous process vents.

Table 4. Comparison of Applicability in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**
Affected source	• Any process that produces a pharmaceutical product • Includes all isolated intermediates that are not subject to another MACT • Applies to formulation of products	• Any process that produces a PAI or integral intermediate • Source may include in the affected source other intermediates that are not subject to another MACT • Applies to formulation of PAI, but not formulation of pesticide products	• Any process that produces an organic chemical and is not subject to another MACT • Concept of isolated intermediate is used to define process boundaries • Applies to formulation of products
New affected source	• An affected source for which construction or reconstruction commenced after the proposal date • A dedicated PMPU with HAP PTE > 10/25 tpy for which construction commenced after the proposal date or reconstruction commenced after 10/21/99	• Same as for subpart GGG except the reconstruction cutoff date for dedicated PAI process units is 9/20/02	• An affected source for which construction or reconstruction commenced after the proposal date • A dedicated MCPU with HAP PTE > 10/25 tpy for which construction or reconstruction commenced after the proposal date
Dedicated process unit	Equipment used to manufacture the same product for a continuous period of at least 6 months	Equipment that is fixed in place and designed and operated to produce only a single product (or co-products)	Equipment that is used exclusively for one process (but storage tanks may be shared)
HAP subject to control	All	• Organic HAP • HCl/Cl_2 • PM HAP (only for bag dumps and product dryers)	• Organic HAP • HCl/Cl_2/HF • PM HAP (only from new sources)
Terminology used to describe emission streams subject to control	Affected streams	Group 1	Group 1

Table 5. Comparison of Process Vent Standards in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**
Threshold for control at existing source	• > 0.9 Mg HAP/yr/process • > 1.8 Mg HAP/yr/facility	• > 0.15 Mg/yr/process of organic HAP • > 6.8 Mg/yr/process of HCl and Cl_2 (includes amount of HCl and Cl_2 generated by combustion control devices) • > 0.01 gr/dscf for PM HAP	• > 10,000 lb/yr/process of organic HAP for BPV • TRE < 5.0 for CPV • > 1,000 lb/yr/process of HCl, Cl_2, and HF
Threshold for control at new source	> 0.9 Mg HAP/yr/facility	Same as for existing source	• > 3,000 lb/yr/process of organic HAP for BPV • TRI < 8.0 for CPV • > 1,000 lb/yr/process of HCl, Cl_2, and HF • > 400 lb/yr/process of PM HAP
Control requirement options for existing source	• Reduce to less than threshold • > 98% for "large" vents (or grandfathered lower levels) • 93% for sum of all other vents per process • 95% for HCl/Cl_2/HF generated in combustion devices • Outlet concentration limits • Specific devices	• > 98% for organic HAP from "large" vents • > 90% for sum of organic HAP from all other vents per process • 94% for sum of HCl/Cl_2 per process • Outlet concentration limits • < 0.01 gr/dscf for PM HAP • Specific devices	• > 95% for sum of organic HAP from BPV if recovered • > 98% for sum of organic HAP from BPV if controlled • > 98% for CPV with TRE < 1.9, or maintain TRE > 1.9 with a recovery device • > 99% or < 0.45 kg/hr for HCl/Cl_2/HF generated by combustion control, or reduce halogen atom mass rate to < 0.45 kg/hr • > 99% for sum of HCl/Cl_2/HF from the process • Outlet concentration limits
Control requirements for new source	• Reduce to less than threshold • > 98% for sum of all vents per process • Outlet concentration limits • Specific devices	• > 98% for sum of organic HAP from all vents per process • > 94% for sum of HCl/Cl_2 if uncontrolled is < 191 Mg/yr • > 99% for sum of HCl/Cl_2 if uncontrolled is > 191 Mg/yr • < 0.01 gr/dscf for PM HAP • Outlet concentration limits • Specific devices	Same as for existing source except the thresholds are lower

Table 6. Comparison of Storage Tank Standards in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**
Threshold for control at existing source	MTVP $\geq$ 13.1 kPa, and capacity > 38 m^3	MTVP $\geq$ 3.45 kPa, and capacity > 75 m^3	MTVP $\geq$ 6.9 kPa, and capacity > 10,000 gal
Threshold for control at new source	Same as for existing source	• Same as for existing source, and • MTVP $\geq$ 16.5 kPa, and capacity > 40 m^3	MTVP $\geq$ 0.69 kPa, and capacity > 10,000 gal
Control requirement options for both new and existing sources	• > 90% if < 75 m^3 • > 95% (or grandfathered 90%) if > 75 m^3 • Outlet concentration limits • Floating roof • Vapor balance • Specific APCD	• > 95% • Outlet concentration limits • Floating roof • Vapor balance • Specific APCD	• > 95% • Outlet concentration limits • Floating roof if < 76.6 kPa • Vapor balance • Specific APCD • Return to process or fuel gas system

Table 7. Comparison of Wastewater Standards in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**
Threshold for control at existing source	Wastewater at POD (excluding maintenance wastewater) with • PSHAP ≥ 1,300 ppmw and ≥ 0.25 Mg/yr • Total PSHAP and SHAP ≥ 5,200 ppmw and ≥ 0.25 Mg/yr • Scrubber effluent if it contains PSHAP removed from affected PV stream	• Process wastewater at POD or effluent from a scrubber used to control PAI process emissions with • ≥ 10 ℓpm and ≥ 1,000 ppmw of HON Table 9 HAP • ≥ 10,000 ppmw of HON Table 9 HAP • Each maintenance wastewater stream with > 5.3 Mg of HON Table 9 HAP per discharge event	Process wastewater at POD with • ≥ 1 ℓpm and ≥ 1,000 ppmw of total PSHAP and SHAP • ≥ 30,000 ppmw and ≥ 1 tpy SHAP • ≥ 10,000 ppmw total PSHAP and SHAP
Threshold for control at new source	Same as for existing source	Same as for existing source	• Same as for existing source, and • Process wastewater with ≥ 0.02 ℓpm and ≥ 10 ppmw of any individual HON Table 8 HAP
Maintenance wastewater	Exempt from all wastewater requirements except those specific to maintenance wastewater	Subject only to requirements for maintenance wastewater, except as noted above	Subject only to requirements for maintenance wastewater
Wastewater from cleaning operations	Definition of maintenance wastewater states that wastewater from cleaning operations is not maintenance wastewater	Definition of process wastewater states that it includes water used to clean process equipment	Definition of maintenance wastewater states that wastewater from routine cleaning operations as part of batch operations is not maintenance wastewater

Table 7. Comparison of Wastewater Standards in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Treatment requirement options for existing source			
• Nonbiological	• PSHAP: < 50 ppmw or ≥ 99% • SHAP: < 520 ppmw or ≥ 90%	• Design steam stripper • > 99% or > Fr • < 50 ppmw • AMR > RMR	Same as subpart MMM
• Biological	• Enhanced biotreatment for SHAP • ≥ 95% for all PSHAP and SHAP in wastewater sent to treatment unit • ≥ 99% for PSHAP and ≥ 90% for SHAP	• ≥ 95% for all HON Table 9 HAP in wastewater sent to treatment unit • AMR > RMR	Same as subpart MMM
• Other	• Offsite treatment • RCRA-permitted unit	Same as subpart GGG	Same as subpart GGG
Treatment requirement options for new sources	Same as for existing sources except if SHAP > 110,000 ppmw and total PSHAP and SHAP from the PMPU is ≥ 1 Mg/yr, then must either reduce SHAP by > 99% or use RCRA-permitted unit	Same as for existing sources, except if wastewater from all PAI process units at an affected source has ≥ 2,100 Mg/yr of HON Table 9 HAP, then must reduce by ≥ 99% or use RCRA-permitted unit	Same as for existing sources, except lower threshold means more streams may be subject to control requirements
Emission suppression requirements for waste management units at new and existing sources	Same as for subpart FFFF	Same as for subpart FFFF, except: • no option to use a fixed roof on a wastewater tank that is used for heating, treatment by exothermic reaction, or sparging • no option to vent sewer lines that are water sealed at the drains and first downstream junction box	• See Flowcharts 3 and 4 of Appendix C in this workbook • In addition, for wastewater discharged to offsite biotreatment, the offsite WMUs up to the activated sludge unit need not be covered if the wastewater contains < 50 ppmw PSHAP, and SHAP losses are determined to be < 5% prior to the activated sludge unit

Table 8. Comparison of Equipment Leak Standards in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**
Threshold for control at existing source	Components that are in organic HAP service ≥ 300 hr/yr	Same as for subpart GGG	Same as for subpart GGG

Requirements for existing sources	Implement LDAR program with
	• Annual M21 monitoring for connectors in gas/vapor and light liquid service (or skip monitoring if few leakers)
	• Monthly M21 monitoring for valves in gas/vapor and light liquid service (or skip monitoring if few leakers)
	• Quarterly M21 monitoring for pumps/agitators in light liquid service (monthly for pumps if high number of leakers)
	• Weekly sensory inspection of pumps/agitators for indications of liquids dripping
	• Cap open-ended valves and lines
	• Closed purge, closed loop, or closed-vent system for sampling connections
	• Seal system requirements for compressors
	• M21 monitoring after releases or replace rupture disk for PRVs in gas and vapor service
	• M21 monitoring within 5 days of sensory indication of leak or eliminate the indications of a leak for pumps, valves, connectors, and agitators in heavy liquid service, PRVs in liquid service, and instrumentation systems
	• Pressure test process as an alternative to above monitoring
	• Repair leaks within 15 days
		Same as for subpart GGG	• Implement the subpart UU LDAR program for any processes, which is same as subpart GGG, except:
			  • skip monitoring frequency for connectors is different
			  • quality improvement program is required for pumps if "high" percentage leak
			  • monthly baseline monitoring for pumps and agitators
			• Implement the subpart TT LDAR program for processes that have no continuous process vents. Same as subpart UU except:
			  • higher leak definition for pumps and valves
			  • only sensory monitoring for connectors
			  • different skip monitoring options for pumps
			  • no pressure testing option
			• Implement the CAR LDAR for any process

Requirements for new sources	Same as for existing sources	Same as for existing sources	Same as for existing sources except the subpart TT option is not allowed

Table 9. Comparison of Transfer Operation Standards in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Threshold for control at new and existing sources	None	None	Loading rack for tank trucks and/or railcars that loads > 0.65 million ℓ/yr of material with an average partial pressure ≥ 1.5 psia

Control requirement options for new and existing sources	None	None	• For organic HAP emissions
			  • > 98% reductions in organic HAP, or
			  • < 20 ppmv TOC or total organic HAP, or
			  • use flare, or
			  • route to fuel gas system, or
			  • route to process, or
			  • vapor balance
			• For halogenated emission streams that are controlled with combustion
			  • reduce total HCl/Cl_2/HF by > 99%, to < 0.45 kg/hr, or to < 20 ppmv, or
			  • reduce halogen atom mass rate to < 0.45 kg/hr or < 20 ppmv

Table 10. Comparison of Initial Compliance Requirements in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF

Demonstration for vent streams controlled with APCD	Same as for subpart FFFF, except:
	• No TRE calculation because no distinction between BPV and CPV
	• More calculation options are specified for emission from heating and depressurization
	• Conduct performance tests as specified in §63.1257 of subpart GGG
	• Calculate flow-weighted average flowrate for "large" vents to determine those that are subject to 98% control
		Same as for subpart GGG	• Calculate TRE for CPV or designate as Group 1
			• Calculate uncontrolled emissions from BPV or designate as Group 1 (under certain conditions)
			• Calculate uncontrolled $HCl/Cl_2/HF$ emissions from BPV and CPV
			• Do not need to calculate uncontrolled emissions from transfer operations, storage tanks, or wastewater (except as they affect an emissions profile)
			• Determine controlled emissions
			  • using specified equations when APCD is a condenser
			  • conduct performance test or design evaluation for "small" APCD
			  • conduct performance test for "large" APCD
			  • calculations as necessary to show process-based percent reduction for BPV
			• Conduct performance test as specified in subpart SS (or subpart G for wastewater vents) or conduct design evaluation as specified in §63.1257, except as follows:
			  • determine compliance under worst-case conditions for BPV
			  • develop emissions profile as specified in §63.1257 to determine the situation that produces the worst-case conditions
			• Initial M21 inspection of CVS

Table 10. Comparison of Initial Compliance Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Demonstrate initial compliance with storage tank standards	Same as for subpart FFFF except that a fuel gas system would be subject to the same requirements as any vent stream to a combustion device, and there is no "return to process" compliance option	Same as for subpart GGG	See slide #4 in section 6 of this workbook
Demonstrate initial compliance with wastewater standards	Same as for subpart FFFF except there is no design steam stripper treatment option (must conduct a performance test or design evaluation for all steam strippers), and the offsite certification exemption does not apply	Same as for subpart FFFF except the offsite certification exemption does not apply	• Determine or designate Group 1 wastewater streams • Conduct performance tests or design evaluations (as specified in subpart G) for most types of treatment units, and conduct initial inspection of waste management units (see slides 5 and 6 in section 6 of this workbook) • If the wastewater is transferred offsite for treatment, the treatment facility must submit written certification to EPA that it will manage and treat Group 1 wastewater as specified in the rule (certification is not required if the wastewater is to be treated as hazardous waste)

Table 11. Comparison of Ongoing Compliance Requirements in Subparts GGG, MMM, and FFFF

	Requirements		
Parameter	**Subpart GGG**	**Subpart MMM**	**Subpart FFFF**

Parameter monitoring to demonstrate ongoing compliance with a percent reduction standard or outlet concentration limits	Same as for subpart FFFF, except:
	• periodic verification applies even if APCD is not used for any BPV
	• for scrubbers, caustic strength is not a specified parameter, and pressure drop is an alternative to liquid flow
	• for regenerative carbon adsorbers, must conduct annual check for bed poisoning
	• this rule specifies requirements for nonregenerative carbon adsorbers
	• for catalytic incinerators, this rule does not include the option to monitor temperature before the catalyst bed and check catalyst activity
	• slight differences in accuracy requirements for temperature monitoring devices
	• includes accuracy requirements for scrubber liquid flow and pressure drop monitoring devices
	• requires annual calibration of all monitoring devices
	• includes exemptions for periods of PRM of CCCDs
		Same as for subpart GGG except does not include requirements for CCCDs	• If APCD is used for BPV and inlet HAP load is < 1 tpy: periodic verification that the APCD is working properly
			• If APCD is not used for BPV or the inlet HAP load is > 1 tpy: continuous parameter monitoring is required
			• If the APCD is not used to control wastewater emissions, follow subpart SS requirements regarding parameters to monitor, accuracy requirements for some monitoring devices, and calibration frequency (see Table 3 in this Appendix and section 7 of the presentation slides)
			• If APCD is used to control wastewater emissions, follow procedures in subpart G, which are similar to those in subpart SS, but subpart G does not address the same group of APCDs
			• Data averaging period options:
			  • daily for any vent stream
			  • operating block (only allowed for BPV)
			• If initial compliance is based on a performance test, establish parameters:
			  • based on measurements during the 3 test runs
			  • may supplement with engineering assessments or manufacturer's recommendations
			  • may set separate levels for different operating conditions (i.e., batch)
			• For a small control device, may set operating limits as part of design evaluation

Table 11. Comparison of Ongoing Compliance Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**
Alternative standard	Same as for subpart FFFF except: • subpart GGG does not require compliance with appendix F, procedure 1 for CEMS meeting PS 8 • subpart GGG includes two parameter monitoring options (one for combustion devices and one for noncombustion devices) as an alternative to correcting measured concentrations for supplemental gases	Same as for subpart GGG except: • subpart MMM does not specify requirements for HCl/Cl_2 CEMS • subpart MMM includes a parameter monitoring alternative to correcting concentrations for supplemental gases only for combustion devices • subpart MMM does not include the parameter monitoring option for scrubbers used to control HCl/Cl_2 that is generated by combustion devices	• Continuously monitor TOC and/or $HCl/Cl_2/HF$ (or monitor scrubber parameters for scrubber used to control $HCl/Cl_2/HF$ generated by combustion control) • Install, operate, and maintain according to applicable PS in 40 CFR part 60 appendix B (and appendix F, procedure 1 for CPMS meeting PS 8) • Submit monitoring plan for CEMS other than FTIR meeting PS 15 that is used to monitor $HCl/Cl_2/HF$ if applicable PS has not yet been promulgated • Calibration gas and reporting unit requirements specified in §63.2450(j)(2) • Conduct performance evaluation in accordance with §63.8(e) and include results in NOCS • Averaging period must be daily • Valid data requirements are consistent with requirements for CPMS in §63.999(c)(6)(1) of subpart SS, except data only required for 2 of the 15-minute periods in an hour when calibration, QA, or maintenance are performed • Must correct measured concentrations to account for supplemental gases
Wastewater treatment units	• For biological treatment units, monitor TSS, BOD, and biomass concentration using methods approved by the permitting authority and at a frequency approved by the permitting authority • For other treatment units, request approval to monitor appropriate parameters that demonstrate proper operation	Same as for subpart FFFF	• For steam strippers, continuously monitor steam flow rate, wastewater feed temperature, and wastewater mass flow rate • For other treatment units, request approval to monitor appropriate parameters that demonstrate proper operation

Table 11. Comparison of Ongoing Compliance Requirements in Subparts GGG, MMM, and FFFF (continued)

	Requirements		
Parameter	**Subpart GGG**	**Subpart MMM**	**Subpart FFFF**
Waste management unit inspections	Same as for subpart FFFF	Same as for subpart FFFF	• Initial and semiannual visual inspections for leaks, control equipment failures, and improper work practices • Periodic seal gap measurements for EFR used on wastewater tanks and oil-water separators • Initial M21 inspections for leaks from fixed roofs, covers, and enclosures

Closed-vent system and vapor collection system inspections	Same as for subpart FFFF except does not have the provisions in subpart SS that differ from subpart G	Same as for subpart GGG except does limit inspections of unsafe-to-inspect equipment to no more than annually	• Initial M21 inspections
			• Annual visual inspections if system is constructed of hard-piping
			• Annual M21 inspections if system is constructed of ductwork
			• Written plan with procedures for parts of the system that are designated as unsafe- or difficult-to-inspect
			• The following provisions in subpart SS are not in subpart G
			  • additional calibration gas specified for instruments that have multiple calibration scales
			  • visual indication of a leak is not a leak if M21 is also used and reading is < 500 ppm
			  • limits inspections of unsafe-to-inspect equipment to no more than once per year

Bypass lines around APCDs	Same as subpart FFFF	Same as subpart FFFF	• Continuously monitor using a flow indicator, or • Install car-seal and visually inspect monthly

Table 11. Comparison of Ongoing Compliance Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Inspections for floating roofs on storage vessels	Essentially the same as for subpart FFFF, although the provisions are organized in a different manner and stated using slightly different language	Same as for subpart GGG	• When storage vessel is emptied and degassed (at least every 10 years), inspect the floating roof, deck fittings, and rim seals • Annual inspection of IFR deck, deck fittings, and rim seal through openings in the fixed roof • Annual inspection of secondary seal and inspection every 5 years of primary seal on EFR, including seal gap measurements
LDAR for equipment leaks	See Table 8	See Table 8	See Table 8
Violations	• Rule identified certain exceedances of monitored parameters as violations of the emission limit and others as violations of the operating limit • Lack of sufficient valid data (i.e., an excursion) is also identified as a violation • The rule also indicates the number of violations that would be assigned for multiple exceedances per day or control devices used for multiple processes	Same as for subpart GGG	Rule does not define violations. However, the rule does define "deviations," and any of the events that would trigger a violation under subparts GGG and MMM would be considered as deviations

Table 12. Comparison of Recordkeeping Requirements in Subparts GGG, MMM, and FFFF

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Operating scenarios	Same as for subpart FFFF	Same as for subpart FFFF except calculations of uncontrolled emissions are not required in cases where an emission profile is not required, and subpart MMM does not use the concept of standard batches	• For each MCPU, record all of the information specified in slide #2 of section 8 in this workbook • Keep a schedule or log of operating scenarios, updated each time a new one is put into operation
Records of monitored parameters to demonstrate compliance with percent reduction standards, outlet concentration limits, and wastewater treatment standards	Keep records of all CPMS/CEMS measurements and each measurement of approved parameters for wastewater treatment units	Same as for subpart GGG	• Currently no requirement to keep CEMS records except for days where there is a deviation • Generally must keep daily/block average of CPMS measurements, but there are various options for keeping individual or hourly readings • Keep records as required by the Administrator for wastewater treatment units • Keep records of all periods when pilot flame is absent for flares • Keep regeneration cycle records for carbon adsorbers • Keep records of the cause of periods when operating limits are exceeded
Additional records to demonstrate compliance with percent reduction standard when using at least one APCD that achieves reductions less than the standard	Same as for subpart FFFF	This rule does not use the concept of standard batches. However, if actual operation differs from that described in the operating scenario, a description of the change would be required in a notification of process change	• Keep record of whether each batch was a standard batch • Keep records of uncontrolled and controlled emissions for each nonstandard batch

Table 12. Comparison of Recordkeeping Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Additional records to demonstrate compliance with a process vent mass emission threshold (MMM and FFFF) or an annual mass limit (GGG)	Same as for subpart FFFF except instead of specifying records of the day each batch is completed, this rule specifies keeping records of the number of batches per year for batch processes and the number of operating hours per year for continuous processes	• Record number of batches per year for each batch process and number of operating hours per year for continuous processes • Record daily 365-day rolling summation of uncontrolled emissions • This rule does not use the concept of standard batches, but differences from operating scenarios must be described in the NOCS	• Record of day each batch was completed • Record of whether each batch was a standard batch • Estimated uncontrolled land controlled emissions for nonstandard batches • Records of the daily 365-day rolling summations of uncontrolled emissions

Compliance with standards for storage vessels	Same as for subpart FFFF except a description of the maintenance performed during periods of PRM is not required, and some details of records for floating roofs are slightly different	Same as for subpart GGG	• If using a floating roof: record inspections, seal gap measurements, and other information as specified in subpart WW
			• If vapor balancing, keep records of:
			  • DOT certification
			  • pressure relief setting
			  • leak detection results
			• If venting to an APCD, keep records of:
			  • monitored parameters as specified above
			  • periods of PRM of the control device and the type of maintenance performed

Compliance with inspections for closed-vent systems	Very similar to subpart FFFF except more detailed delay of repair records are required	Same as for subpart GGG	• Keep records identifying parts of the CVS that are unsafe- or difficult-to-inspect along with a written plan for inspecting such equipment • Keep records of data collected for each inspection during which a leak is detected • Keep records of leak repairs or any delay of repair • Keep records documenting the date of inspections when no leaks are detected

Table 12. Comparison of Recordkeeping Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Compliance with standards for wastewater systems	Very similar to subpart FFFF. Minor differences include: • specifically required to keep records of HAP concentrations in wastewater • no requirement to keep records of changes in the location at which a vent stream is introduced to the flame zone of a process heater or boiler	Very similar to subpart FFFF except: • no requirement to develop a maintenance plan • specifically required to keep records of HAP concentration in wastewater	• Keep records of Group 2 determinations • No specific requirement to keep records of Group 1 wastewater stream flows and HAP concentrations, but this information must be included in the NOCS • If wastewater is sent offsite for treatment, keep records of notices that must accompany the wastewater • Develop and retain a maintenance wastewater plan • Keep records documenting required WMU and control device inspections were conducted • Keep records of visual and M21 inspections of vapor suppression equipment • Keep records of seal gap measurements for EFRs on wastewater tanks, various records associated with delay of repair, and records documenting a decision to use an operating extension if a floating roof is determined to be unsafe-to-inspect or an inspection reveals control equipment failure • Keep record of any changes in location at which vent streams are introduced to the flame zone of a boiler or process heater • Keep records identifying parts of emission suppression equipment that are unsafe- or difficult-to-inspect, along with a written plan for inspecting the equipment

Table 12. Comparison of Recordkeeping Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Requirements for bypass lines around control devices	Same as for subpart FFFF	Same as for subpart FFFF	• Keep hourly records of whether the flow indicator was operating and any diversion was detected, or • Keep monthly records of visual inspections of the seal mechanism and the occurrence of all periods when the seal mechanism is broken, the bypass line valve position has changed, or the key for a lock-and-key type lock has been checked out
Compliance with standards for equipment leaks	• Very similar to subpart FFFF if compliance with subpart FFFF is based on the subpart UU requirements • If compliance under subpart FFFF is based on the subpart TT requirements, there would be more recordkeeping differences. For example, only subpart GGG would require records for valve subgrouping, dates of connector M21 monitoring periods, and pressure testing	Same as for subpart GGG	Numerous records required including • equipment IDs • written plans for unsafe- or difficult-to-monitor equipment • information about leaking equipment • monitoring schedules • results of visual inspections • pressure test records
Process unit groups	Not applicable	Keep records of: • the process units in the PUG • the operating time for each process unit in the PUG • each redetermination of the primary product of the PUG	Keep records of: • description of process units in the PUG • rationale for including each process unit in the PUG • calculations to determine or redetermine the primary product of the PUG
Heat exchange systems	Same as for subpart FFFF unless complying by using the physical integrity of the reactor as a surrogate indicator of heat exchanger leaks around the reactor	Same as for subpart FFFF	• Records of monitoring data, leak detections, and repairs as specified in §63.104(f)(1)

Table 12. Comparison of Recordkeeping Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF

General provisions requirements	• §63.10(b)(1) and (3) apply
	• §63.10(c) applies
	• Although §63.10(b)(2) does not apply, most of its provisions are specified in §63.1259(a) and (b), except no records for:
	  • information regarding a waiver of recordkeeping requirements granted by the Administrator under §63.10(f)
	  • adjustments to CMS
	  • emission levels associated with obtaining permission to use an alternative to a RATA for CEMS
		Same as for subpart GGG	• §63.10(b)(1) and (3) apply
			• Most of the provisions in §63.10(b)(2) and (c) apply, except subpart FFFF specifies:
			  • records for CPMS adjustments only if they affect the CPMS reading
			  • that SSM records of actions taken are required only if excess emissions occur
			  • some records in §63.10(c) apply only to CEMS used for the alternative standard (not CPMS)

Table 13. Comparison of Reporting Requirements in Subparts GGG, MMM, and FFFF

	Requirements		
Parameter	**Subpart GGG**	**Subpart MMM**	**Subpart FFFF**
Initial notification, application for approval of construction, notification of CMS performance evaluation	As specified in General Provisions	As specified in General Provisions, except the performance evaluation is only required for CEMS used to comply with the alternative standard	As specified in General Provisions
SSM reports	As specified in General Provisions, using same schedule as for periodic reports	Same as for subpart GGG	• Include records that the procedures specified in your SSMP were followed, documentation of actions taken that were not consistent with the SSMP, and a brief description of each malfunction as part of the compliance reports • No immediate SSM report • Report information only for periods of excess emissions
Precompliance report	• Submit 3 months prior to compliance date • Used to request approval of various procedures that are not specified in the rule	Same as for subpart GGG, except: • must include operation and maintenance plan for any bag leak detectors for PM HAP • does not require documentation of certain procedures used to determine HAP concentration in wastewater	• Same as for subpart MMM, but also must include discussion of control measures for emission streams with energetics and peroxides that are not controlled to levels of the standard because of undue safety hazards • See slide #4 in section 8 for list of items to include in precompliance reports

Table 13. Comparison of Reporting Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	Subpart MMM	Subpart FFFF
Notification of compliance status	Same as for subpart FFFF, except: • only a listing of operating scenarios, rather than the operating scenarios themselves, must be submitted • must identify anticipated periods of PRM of a CCCD during the period between the compliance date and the end of the period covered by the first period report and include rationale for why the PRM must be performed while a process vent will be operating	Same as for subpart FFFF except also • must identify the percentage of production that is anticipated to be used as a PAI in the first 3 years after the compliance date • must identify anticipated periods of PRM of APCD used to control storage tank emissions	• Submit all information needed to demonstrate compliance, including applicability determinations; operating scenarios; performance tests; identification of emission points subject to overlapping requirements and storage tanks for which vapor balancing is used; information about equipment subject to LDAR; and records of process units that are part of process unit groups. See slides 12 and 13 in section 8 for a list • Due 150 days after compliance date • Currently the rule does not require the signature of a responsible official on the report; this oversight will be corrected with an amendment
Compliance report schedule	• Generally submit semiannually 60 days after end of 6-month reporting periods • First reporting period begins on NOCS due date • Quarterly reporting is required after certain exceedances and if a new operating scenario is implemented	Same as for subpart GGG except that implementing a new operating scenario does not trigger quarterly reporting	• Semiannual reporting periods of Jan.–June and July–Dec., except first reporting period is longer than 6 months • Submit reports on Aug. 31 and Feb. 28 • First reporting period begins on the compliance date

Table 13. Comparison of Reporting Requirements in Subparts GGG, MMM, and FFFF (continued)

Parameter	Requirements		
	Subpart GGG	**Subpart MMM**	**Subpart FFFF**

Compliance report content	• All CMS records specified in §63.10(e)(3)
	• Monitoring data (including daily/block average), operating logs and operating scenarios and duration of excursions for days when the average is out of compliance (and the duration of deviations or CMS downtime threshold for the reporting period is met)
	• Other records same as for subpart FFFF, except:
	  • Not required to describe anticipated periods of PRM for APCD used to control emissions from storage tanks
	  • Must identify periods of PRM for a CCCD during the current reporting period, and anticipated periods of PRM during the next reporting period
	  • LDAR records are similar to those in subpart UU except there are no QIP requirements or records of valve subgrouping
	  • No specific requirement to submit information on improper work practices or control equipment failures found during inspections of waste management units
	  • For CVS inspections during which leaks are detected, must submit record of instrument and operator ID
	  • No PUG records
		Same as for subpart GGG, except:
		• new operating scenarios are submitted in the notification of process change
		• must include updates to the corrective action plan for a fabric filter used to control PM HAP
		• subpart MMM (like subpart FFFF) does specifically require submission of waste management unit inspection results when a control equipment failure or improper work practice is identified
		• PUG records as in subpart FFFF
			• Although §63.10(e)(3) does not apply, §63.2520(e)(5)(iii) specifies that most of the same information must be submitted for deviations that occur when CMS are used to demonstrate compliance, and all of the applicable information must be submitted for each deviation because there is no reporting threshold based on duration of excess emissions or CMS downtimes (see slides 15–17 in section 8 for a list of information to submit)
			• Also must submit the following for deviations from limits where a CMS is used to comply:
			  • daily/block averages
			  • operating logs
			• If a deviation occurs where CMS are not used to demonstrate compliance, must submit the information specified on slide #14 in section 8
			• Other records to submit
			  • new operating scenarios
			  • diversions or possible diversions to bypass around APCD
			  • PRM for control devices used to control emissions from storage tanks
			  • results of inspections and seal gap measurements for floating roofs used on storage tanks
			  • results of inspections for leaks, control equipment failure, and improper work practices for waste management units
			  • monitoring data that indicate a wastewater treatment unit is out of compliance
			  • leaks detected in CVS and emission suppression equipment
			  • various LDAR records, including the number of leaking components, components not repaired, pressure test results, and QIP results. Note that subpart TT specifies less detailed reporting requirements than subpart UU
			  • records of process units added to a PUG, and records of primary product

Table 13. Comparison of Reporting Requirements in Subparts GGG, MMM, and FFFF (continued)

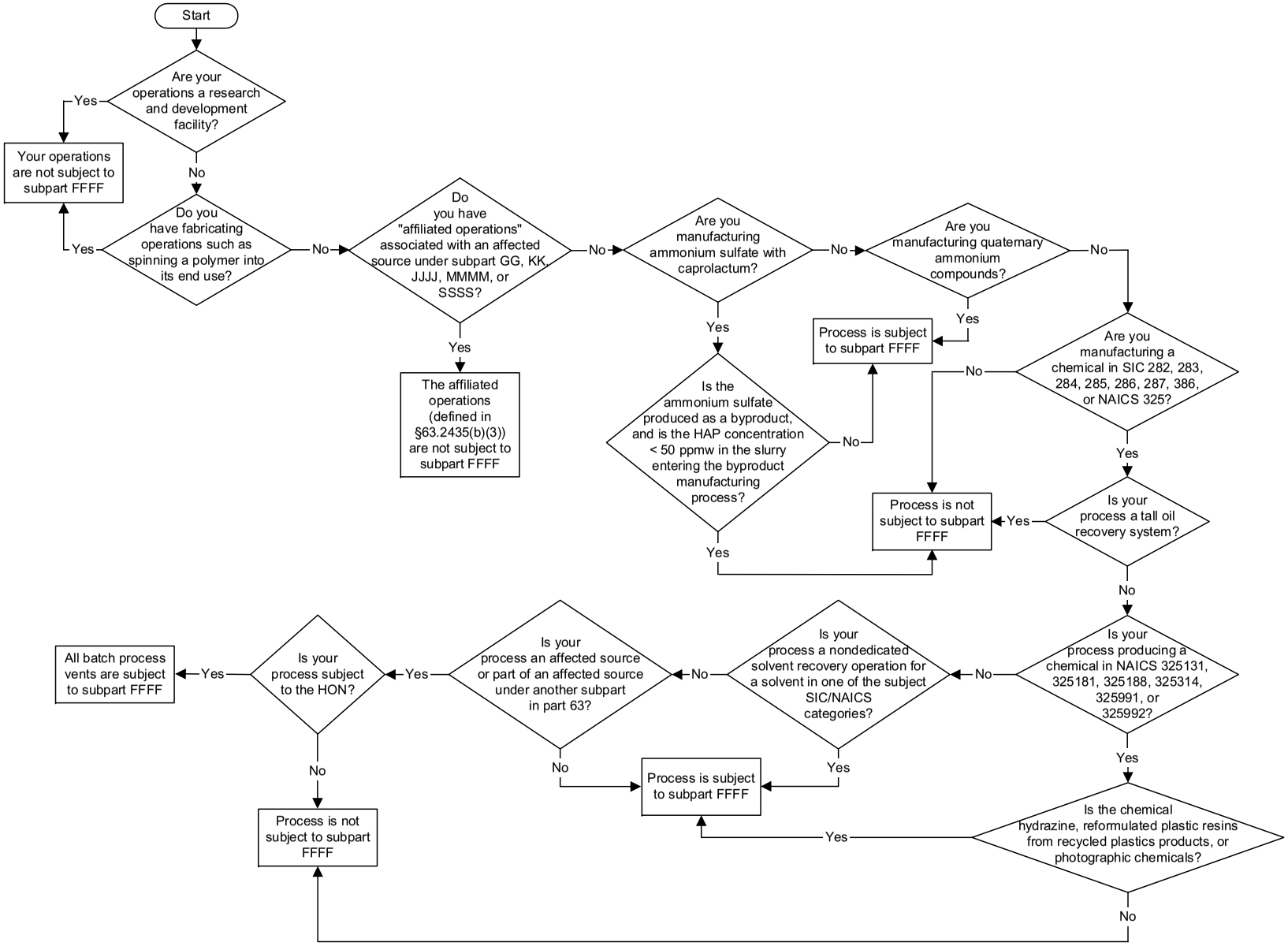
	Requirements		
Parameter	**Subpart GGG**	**Subpart MMM**	**Subpart FFFF**

Notification of process change	Same as for subpart FFFF, except:
	• does not include language clarifying that changes within the scope of an operating scenario are not to be reported
	• does not require notice for changes from Group 2 to Group 1 status
		Same as for subpart GGG	• Describe in compliance reports changes to any of the information submitted in the NOCS
			• Provide documentation of the following at least 60 days before planned change
			  • changes to any items in the precompliance report
			  • change in status of a control device from small to large
			  • change in status of an emission point from Group 2 to Group 1

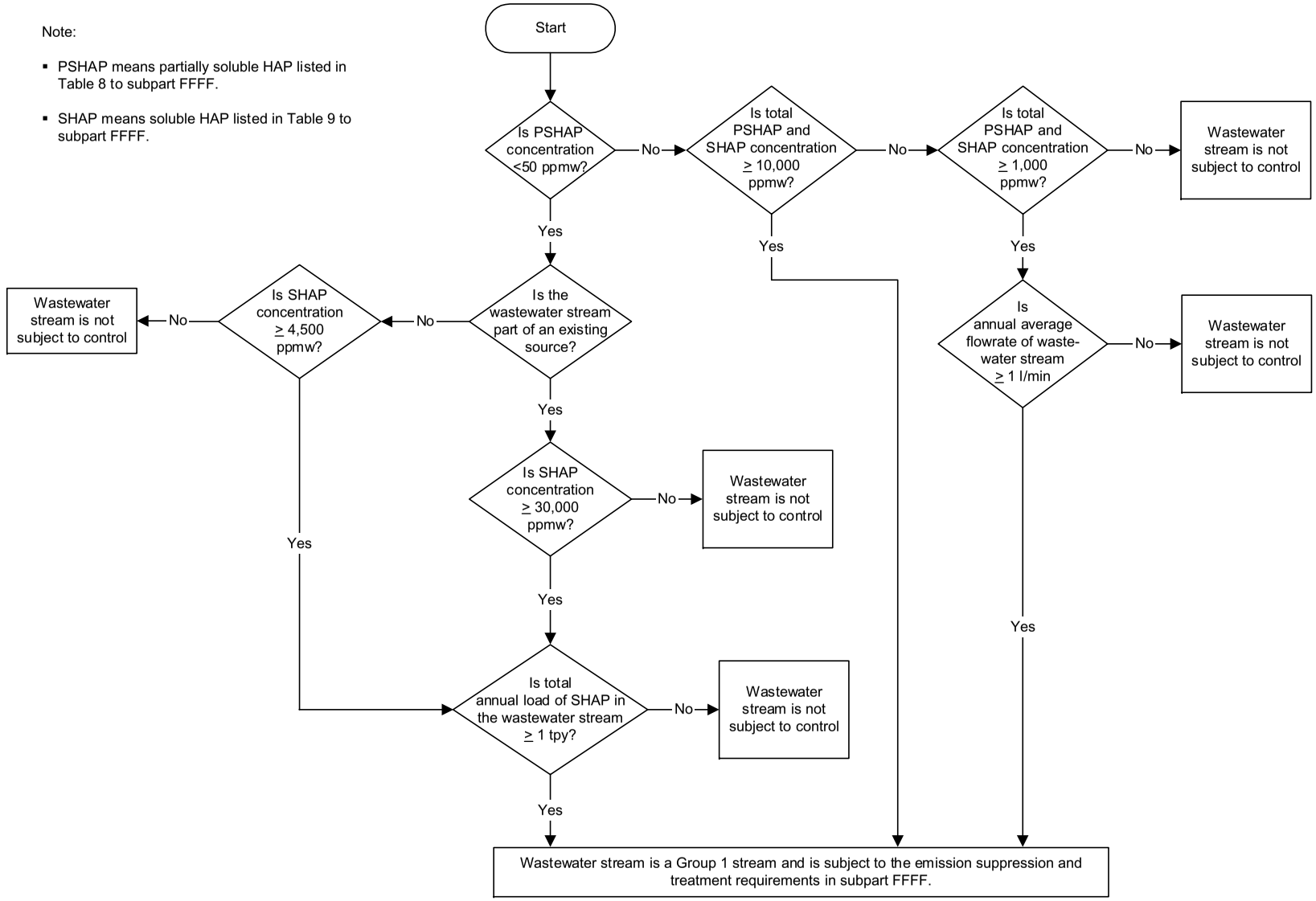
Appendix C

- Applicability and Compliance Flowcharts

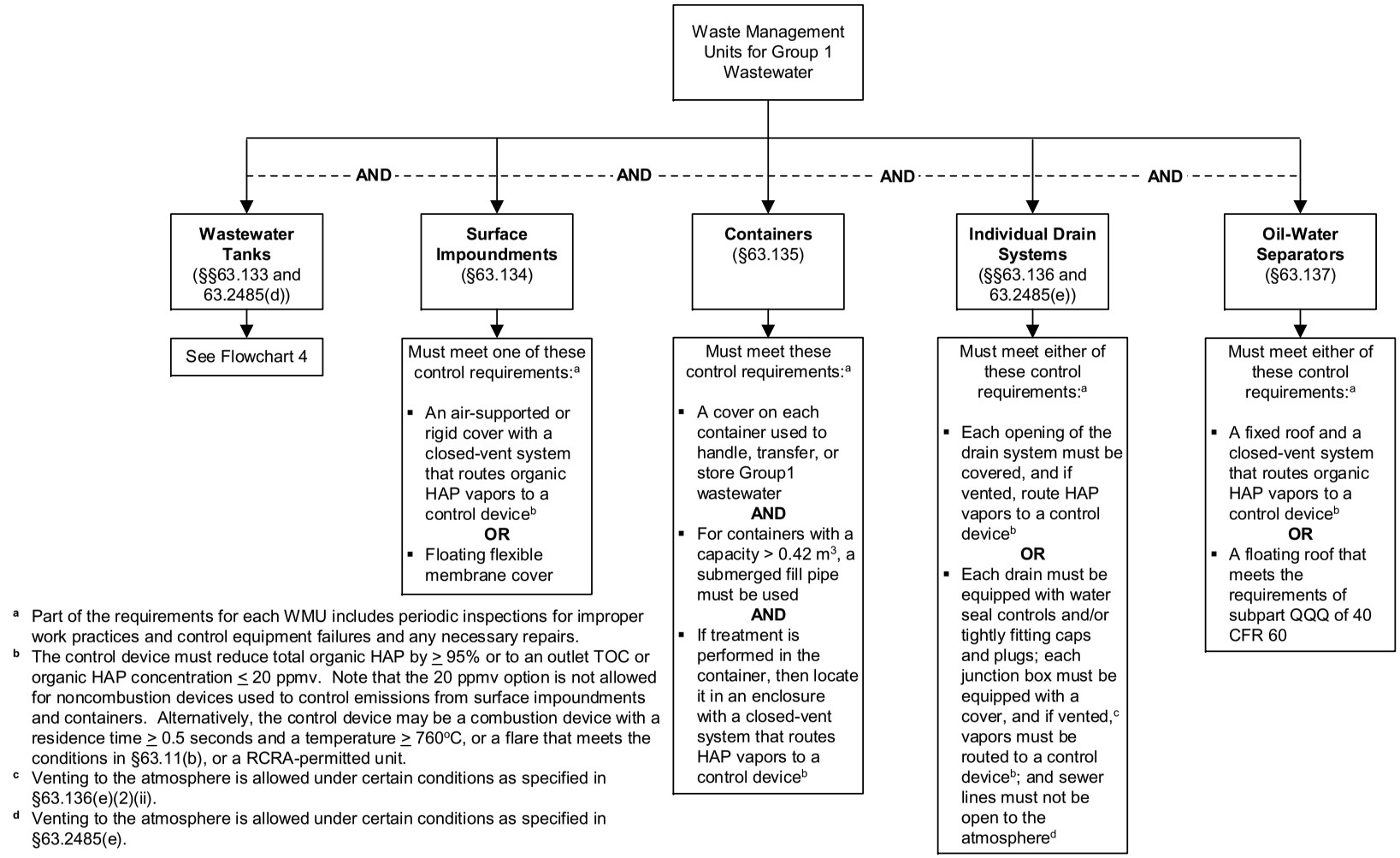
[This page intentionally left blank.]



Flowchart 1. Applicability for subpart FFFF.



Flowchart 2. Applicability determination for wastewater streams.



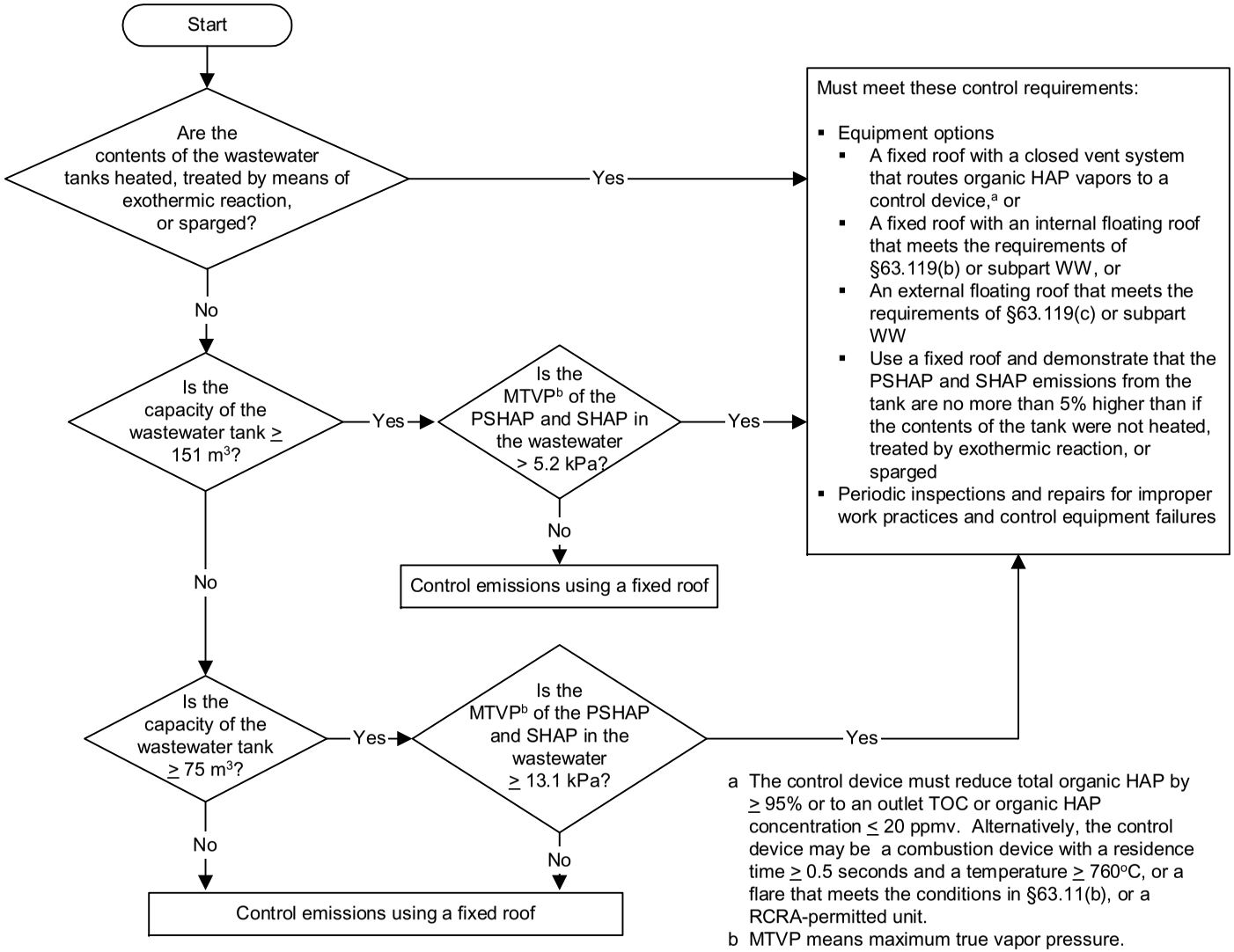
[a] Part of the requirements for each WMU includes periodic inspections for improper work practices and control equipment failures and any necessary repairs.

[b] The control device must reduce total organic HAP by ≥ 95% or to an outlet TOC or organic HAP concentration ≤ 20 ppmv. Note that the 20 ppmv option is not allowed for noncombustion devices used to control emissions from surface impoundments and containers. Alternatively, the control device may be a combustion device with a residence time ≥ 0.5 seconds and a temperature ≥ 760°C, or a flare that meets the conditions in §63.11(b), or a RCRA-permitted unit.

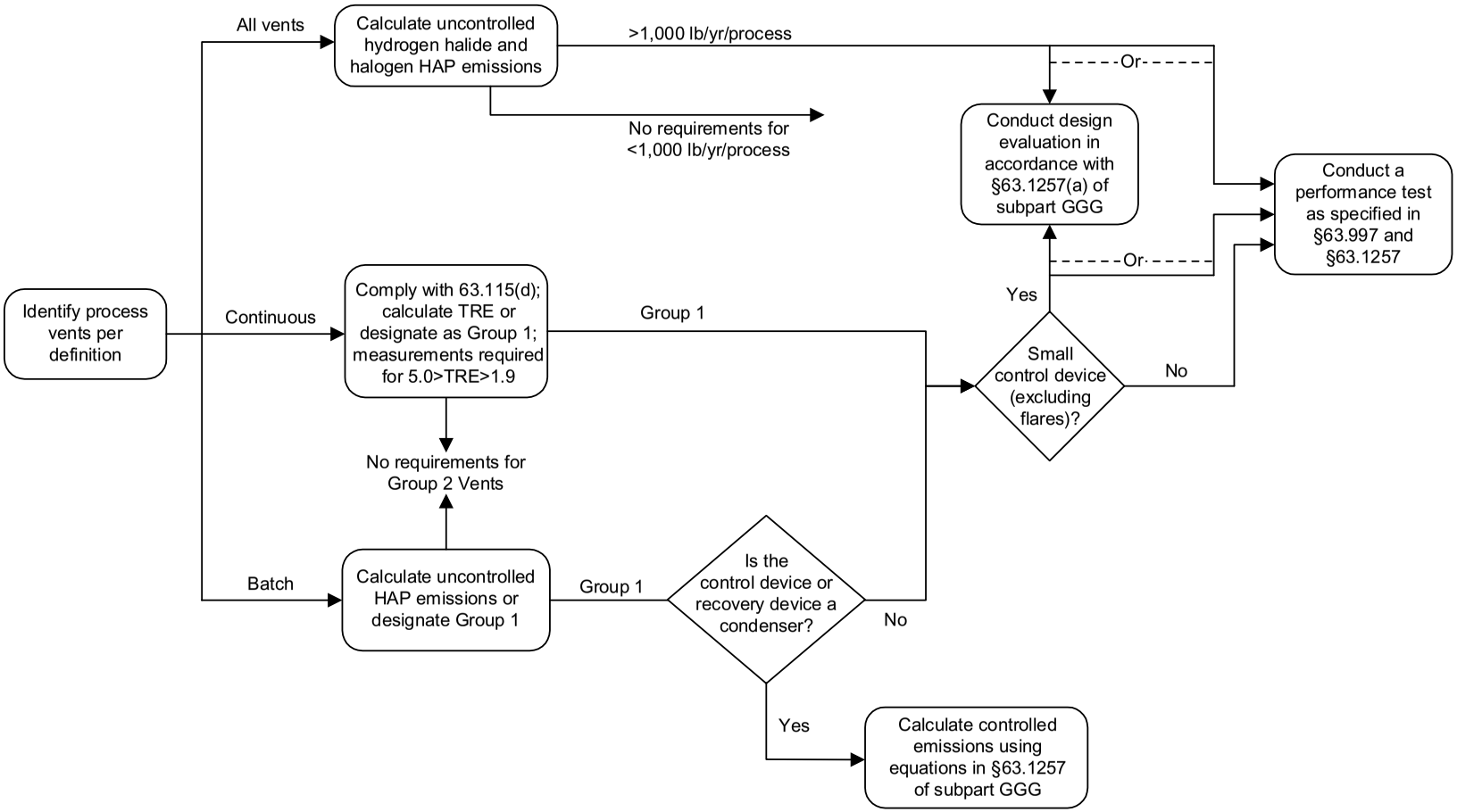
[c] Venting to the atmosphere is allowed under certain conditions as specified in §63.136(e)(2)(ii).

[d] Venting to the atmosphere is allowed under certain conditions as specified in §63.2485(e).

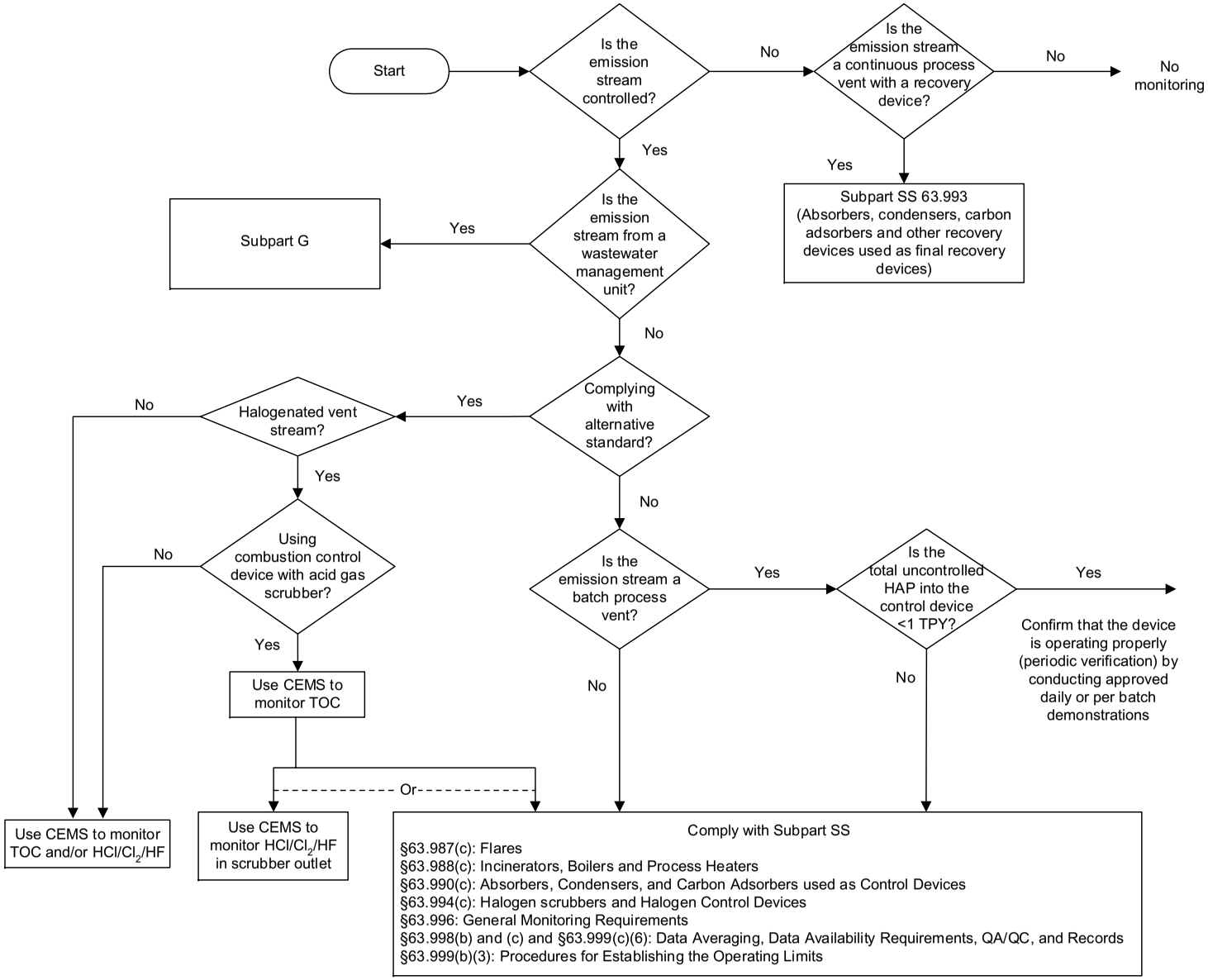
Flowchart 3. Emission suppression requirements for waste management units.



Flowchart 4. Emission suppression requirements for wastewater tanks.



Flowchart 5. Initial compliance for process vents.



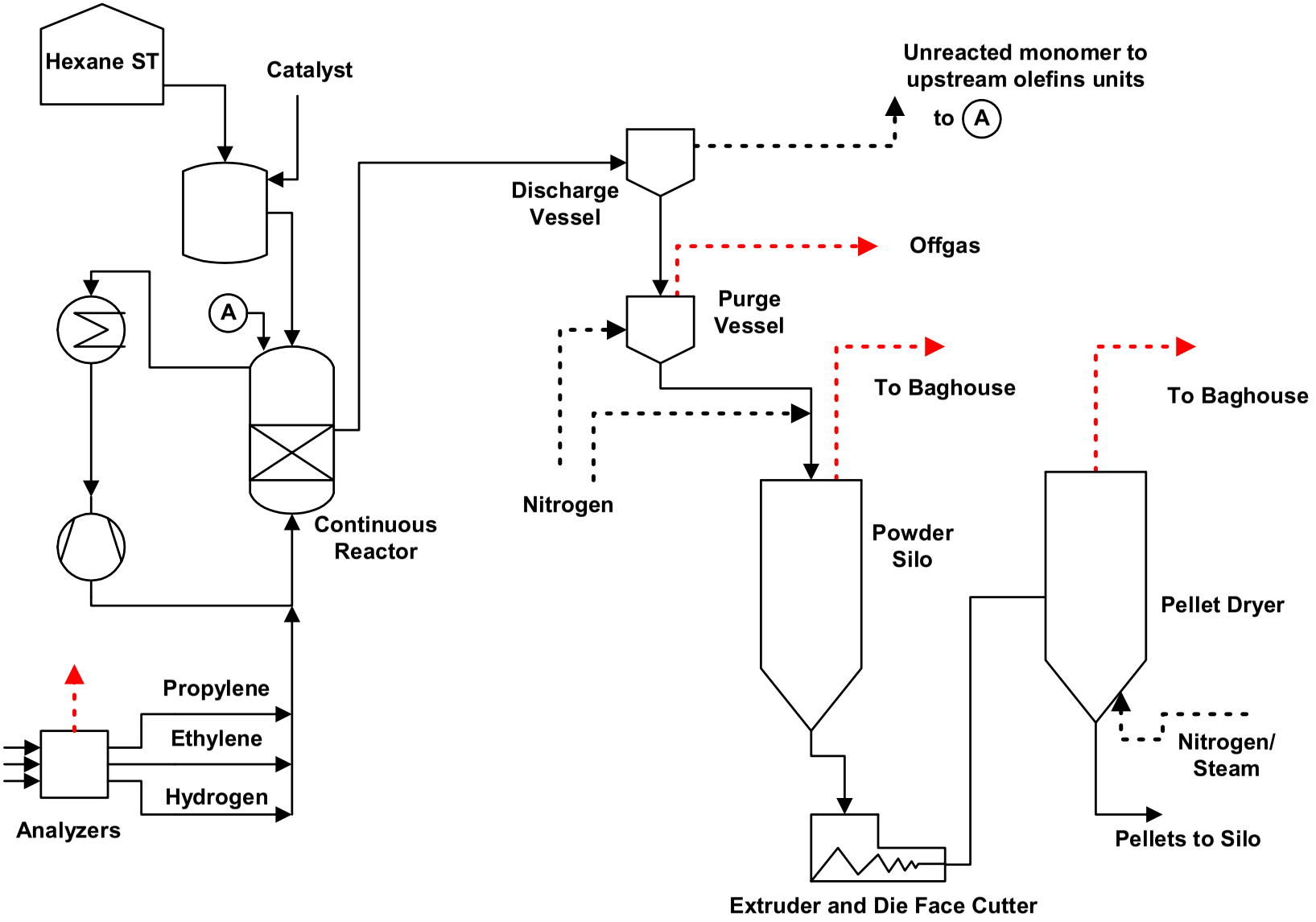
Flowchart 6. Monitoring for vent streams.

Appendix D

- Case Study Data

[This page intentionally left blank.]

Case Study No. 1



Process Vent Characteristics for Case Study No. 1

Vent	Regulated Process Vent Under the MON?	Comment	Regulated as a Batch or Continuous Vent?	Vent Stream Characteristics			
				Flowrate (scfm)	HAP Concentration (ppmv)	Hours of Operation	HAP Emissions, lb/yr
Analyzer Building	No	They have no HAP	NA				
Purge Vessel	Yes		Batch	150	300	8,400	4,980
Powder Silo	No	Less than 50 ppmv HAP	NA	150	20		
Pellet Dryer	No	Less than 50 ppmv HAP	NA	150	ND		

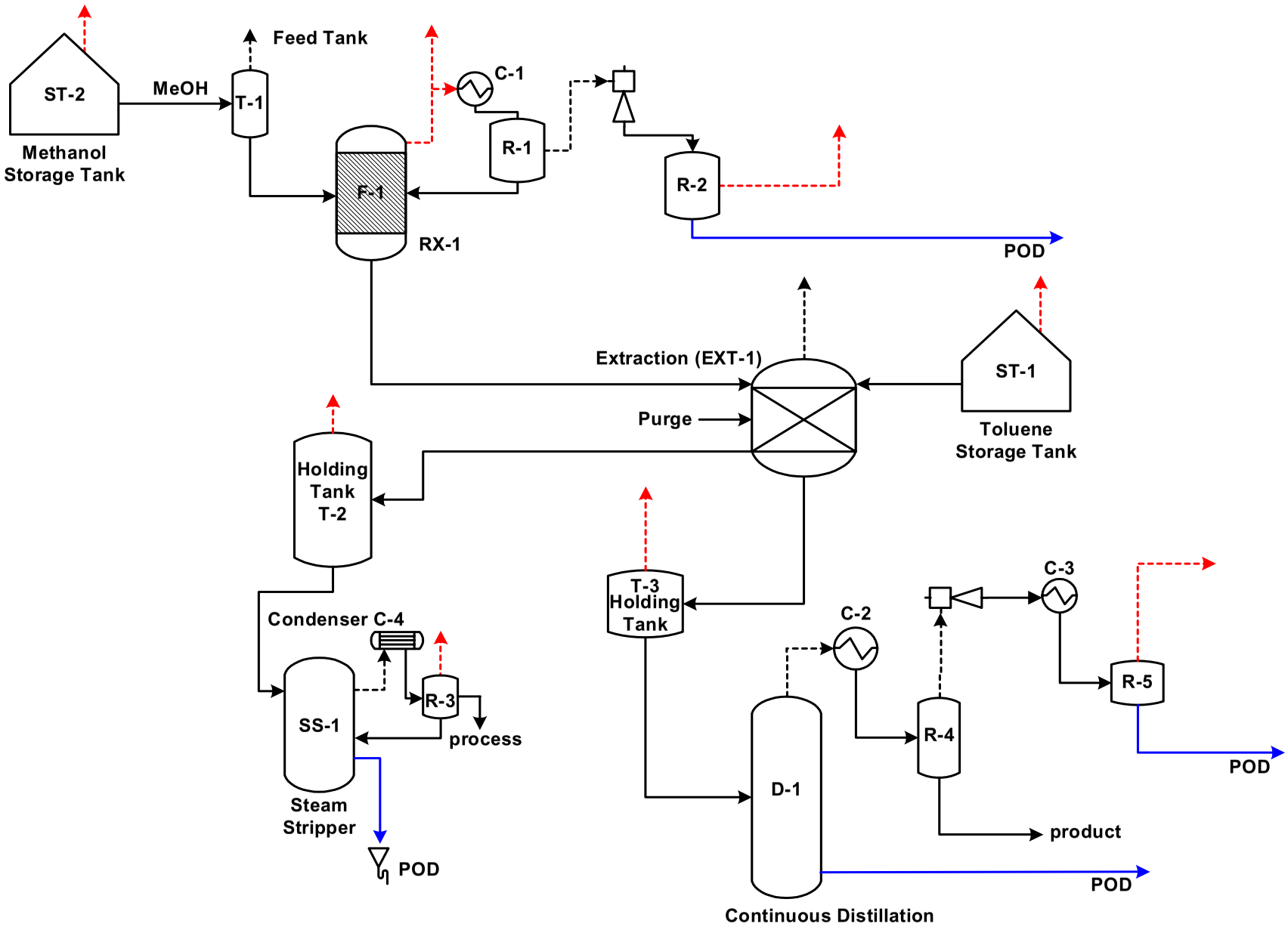
Conclusion: None of the vents are Group 1, so none require control.

Storage Tank Characteristics for Case Study No. 1

Storage Tank Number	Material	Type	Capacity Gallons		MTVP (kPa)	Group
1	Hexane	Fixed roof	15,000	57	20	1

This tank would require control under the MON.

Case Study No. 2



Assumptions for Case Study No. 2

This case study does not represent any single process but instead was developed to illustrate how the standard could be implemented on a model process. Presented below are assumptions used to develop emission calculations.

1. The reactor and upstream batch unit operations are operated for 2,000 batches/yr.

2. The steam stripper operates at 120°C.

3. To simplify the illustration, the emission calculations ignore the volumes of non-volatile reactants and products.

4. We assumed the contents of receivers were equal to the contents of reactor and disitllation column at the initiation of vacuum activities.

5. For heatup activities, the still pot volume was assumed to be 1,000 gallons, while the reactor volume was assumed to be 6,000 gallons.

6. The aqueous phase from the extraction contains 20% of the toluene and 80% of the methanol; the organic phase contains the remainder.

7. The column bottoms from the continuous distillation operation contain 90% by weight of the incoming (feed) water and methanol and only 1% by weight of the incoming toluene.

Example TRE Calculations

Compound	HAP	MW (lbs/hr)	MW (kg/hr)	MW (g/gmol)	MW (gmol/hr)	Conc ppmv	Hj (kcal/gmol)	Hj (kcal/hr)
Toluene	Yes	0.32	0.15	92	1.602101	3,352	901.5	1444.29448
Methanol	Yes	0.19	0.08	32.04	2.624851	5,492	161	422.601053
Water	No	0.16	0.07	18	4.037144	8,447	0	0
Air	No	30.00	13.62	29	469.6552	982,708	0	0
Total		30.67	13.92		477.9193	1,000,000		1866.89553

Etoc (minus ethane) kg/hr	0.23
Ehap kg/hr	0.23
Flow DSCMM	0.19
Ht, Mj/SCM	0.69

TRE Calculation Control Device	a	b	c	d	TRE
Non-halogenated flare	1.935	0.366	-0.00769	-0.00073	8.63
non-halogenated incinerator 0% recovery	1.492	0.0627	0.0318	-0.00116	6.59
non-halogenated incinerator 70% recovery	2.519	0.0118	0.013	0.0479	10.98

None of the above TRE are less than 1.9, therefore, this stream is not a Group 1 continuous stream.

$$TRE = \frac{1}{E_{HAP}}\left[a + b\left(Q_S\right) + c\left(H_T\right) + d\left(E_{TOC}\right)\right]$$

Where:

E_{HAP} = Emission rate of total organic HAP, kg/hr
Q_S = Vent stream flow rate, scmm
H_T = Vent stream net heating valve, MJ/scm
E_{TOC} = Emission rate of TOC (minus methane and ethane), kg/hr.

Summary of Batch Process Vent Emissions

Equipment ID	Emission Event	Materials	Uncontrolled Emissions lbs/batch	Control Devices	Controlled Emissions lbs/batch	Calculation	Assumptions
T-1	Feed Tank Charge	Water				Displacement	Single Phase: Raoults Law
		Methanol	0.36		0.36		
		Toluene					
RX-1	Reactor Charge	Water	0.03		0.03	Displacement	Single Phase: Raoults Law
		Methanol	0.04		0.04		
		Toluene					
RX-1	Reactor Heatup	Water	0.09	C-1	0.03	Heat Up	Single Phase: Raoults Law
		Methanol	0.07		0.03		
		Toluene	0.00		0.00		
RX-1	Reactor Vacuum Distillation	Water	1.21		1.21	Vacuum operation	Single Phase: Raoults Law
		Methanol	1.42		1.42		
		Toluene	0.00		0.00		
EXT-1	Charge to Extraction	Water	0.33		0.33	Displacement	Single Phase: Raoults Law
		Methanol	0.31		0.31		
		Toluene					
EXT-1	Charge Toluene to Extraction	Water	0.11		0.11	Displacement	2-phase Raoult's Law
		Methanol	0.11		0.11		
		Toluene	0.70		0.70		
EXT-1	Purge Extraction	Water	2.40		2.40	Purge	2-phase Raoult's Law
		Methanol	2.62		2.62		
		Toluene	17.46		17.46		
T-2	Charge Aqueous Phase to Hold Tank	Water	0.28		0.28	Displacement	Single Phase: Raoults Law
		Methanol	0.26		0.26		
		Toluene	0.03		0.03		
SS-1	Charge Stripper	Water	0.28		0.28	Displacement	Single Phase: Raoults Law
		Methanol	0.26		0.26		
		Toluene	0.03		0.03		
SS-1	Strip aqueous mix	Water	0.04		0.04	Heatup/Distill	Single Phase: Raoults Law
		Methanol	0.04		0.04		
		Toluene	0.00		0.00		
R-3	Stripper Receiver Charge	Water	0.05		0.05	Displacement	2-phase Raoult's Law
		Methanol	0.35		0.35		
		Toluene	0.07		0.07		

Methanol	5.84		5.77
Toluene	18.30		18.30

Total, lb/batch	**24.14**		**24.06**
Control Efficiency	**0.30%**		
Batches/yr	**2000**		
lb/yr	**48270.65**		**48124.74**

Therefore, 98% control required for Batch Vents

Case Study Emission Calculations

Displacement Calculations

Subpart GGG Equation 11 is used to calculate emission events resulting from the filling of vessels as follows:

$$E = \frac{(V)}{(R)(T)} \sum_{i=1}^{n} (P_i)(MW_i)$$

Where:

E	=	mass of HAP emitted
V	=	volume of gas displaced from the vessel
R	=	ideal gas law constant
T	=	temperature of the vessel vapor space
P_i	=	partial pressure of the individual HAP
MW_i	=	HAP molecular weight.

When a condenser is used for control, the receiver or exhaust gas temperature is used in place of the vessel vapor space temperature. These calculations also assume that the partial pressure of each component is based on the vessel's liquid contents at the condenser temperature. The following table presents the results of using this equation on the case study:

Results of Displacement Calculations for the Case Study

Emission Event	Material	Volume Displaced, gal	Temperature, °C	Moles, lbmol	Mol Fraction	Partial Pressure, mmHg	Emissions, lb
Feed Tank Charge	Water	200	25	0	0.00	0	0
	Methanol			41	1.00	125	0.36
	Toluene			0	0.00	0	0
Reactor Charge	Water	200	25	371	0.90	21	0.03
	Methanol			41	0.10	12	0.04
	Toluene			0	0.00	0	0.00
Charge to Extraction	Water	996	37	371	0.90	42	0.33
	Methanol			40	0.10	22	0.31
	Toluene			0	0.00	0	0.00
Charge Toluene to Extraction	Water	343	37	371	0.90	42	0.11
	Methanol			40	0.10	22	0.11
	Toluene			27	1.00	51	0.70
Charge Aqueous Phase to Hold Tank	Water	864	37	296	0.89	42	0.28
	Methanol			32	0.10	22	0.26
	Toluene			5	0.02	1	0.03
Charge Stripper	Water	864	37	296	0.89	42	0.28
	Methanol			32	0.10	22	0.26
	Toluene			5	0.02	1	0.03
Stripper Receiver Charge	Water	148	37	1	1.00	47	0.05
	Methanol			16	0.75	172	0.35
	Toluene			5	0.25	13	0.07

Case Study
Emission Calculations

Purging

Emissions from purging operations are calculated using Equation 12 of Subpart GGG as follows:

$$E = \sum_{i=1}^{n} P_i MW_i \frac{(V)(t)}{(R)(T)} \frac{P_T}{(P_T - \sum_{j=1}^{m} (P_j))}$$

Where:

E	=	mass of HAP emitted
V	=	purge flow rate at temperature and pressure of the vessel vapor space
R	=	ideal gas law constant
T	=	temperature of the vessel vapor space, absolute
Pi	=	partial pressure of the individual HAP
Pj	=	partial pressure of individual condensable VOC compounds
PT	=	pressure of the vessel vapor space
MWi	=	molecular weight of the HAP
t	=	time of purge
n	=	number of HAP components
m	=	number of condensable compoents.

Results of Purging Calculations for the Case Study

Event	Material	Flowrate, scfm	Temperature, °C	Duration, hr	Moles, lbmol	Mol Fraction	Partial Pressure, mmHg	Emissions, lb
Purge Extraction	Water	5	25	6	371	0.85	20	2.40
	Methanol				40	0.10	12	2.62
	Toluene				27	1.00	28	17.46

Case Study
Emission Calculations

Heatup:

When a distillation or other operation includes atmospheric venting as a result of vessel vapor space heating up and the vessel content temperature increased to or above the bubble, or boiling point of the mixture, a condenser that cools the exhaust gas stream to a temperature below the bubble point is a process condenser. Uncontrolled emissions are calculated at the receiver outlet using either Equation 13 or 37 of subpart GGG. In this example, we chose to use Equation 13 and supporting Equations 15 and 16 as follows:

$$E = \frac{\sum((P_i^*)(x_i)(MW_i)}{760 - \sum((P_j^*)(x_j)} x\, \Delta\eta$$

$$\Delta\eta = \frac{V}{R}((\frac{(Pa_1)}{T_1}) - (\frac{Pa_2}{T_2}))$$

$$Pa_n = P_{atm} - \sum(P_j)_{Tn}$$

Where:

$\triangle\eta$	=	moles of noncondensables displaced
Pa_n	=	partial pressure of noncondensable gas in the vessel headspace at initial and final temperatures. ***In this example, Pa2 is set equal to 0.***
E	=	emissions of HAP vapor displaced from the vessel being heated
Pi*	=	vapor pressure of each HAP in the headspace at any temperature between the initial and final heatup temperatures
Pj*	=	vapor pressure of each condensable VOC (***actually, of each condensable, including water***) at any temperature between the initial and final heatup tempertures,
V	=	volume of free space in the vessel
R	=	ideal gas law constant.

In this example the bubble point (i.e., 98°C) is determined to be below the operating temperature of the steam stripper. Therefore, the condenser is a process condenser and we estimate uncontrolled emissions using Equation No. 13 with the vapor pressures of HAP and condensables at the temperature of the receiver (i.e., 37 C).

Results of Heating Calculations for the Case Study

Emission Event	Material	Void Space Gal	Temperature °C	Moles, lbmol	Mol Fraction	Partial Pressure, mmHg	Moles Noncond	Emissions, lb
Strip aqueous mix	Water	136	37	296	0.89	42	0.04	0.04
	Methanol			32	0.10	22		0.04
	Toluene			5	0.02	1		0.00

Case Study
Emission Calculations

Vacuum Operation

Emissions from vacuum operations are calculated using Equation No. 33 of Subpart GGG as follows:

$$E = \frac{(La)(t)}{MW_{NC}} \left[\frac{\sum_{i=1}^{n} P_i MW_i}{P_{system} - \sum_{j=1}^{m} P_j} \right]$$

Where:

E	=	mass of HAP emitted from the vacuum operation
La	=	total air leak rate in the system, mass/time
t	=	time of vacuum operation
MWi	=	molecular weight of individual HAP with partial pressures calculated at the temperature of the receiver
MW_{nc}	=	molecular weight of noncondensables
P_i	=	partial pressure of HAP at receiver temperature
Pj	=	partial pressure of condensable at receiver temperature
P_{system}	=	absolute pressure of receiving vessel.

Results of Vacuum Calculations for the Case Study

Emission Event	Material	Leak Rate, lb/hr	Temp of Receiver, °C	Duration, hr	Moles, lbmol	Mol Fraction	Partial Pressure, mmHg	Emissions*, lb or lb/hr
Reactor Vacuum Distillation	Water	30	10	6	370.66	0.90	8	1.21
	Methanol				41.17	0.10	5	1.42
	Toluene				0.00	0.00	0	
Continuous Dist	Water	30	10	NA	74.23	0.71	6	0.16
	Methanol				8.14	0.08	4	0.19
	Toluene				21.66	0.21	3	0.32

* If no duration is specified, as in continuous distillation, emissions are in a lb/hr basis

Case Study
Emission Calculations

Heatup:

When a distillation or other operation includes atmospheric venting as a result of vessel vapor space heating up to a temperature lower than the bubble, or boiling point of the mixture, uncontrolled emissions are calculated using Equations 18, 19, and 20 of subpart GGG.

$$E = MW_{HAP}\, x \left[N_{AVG}\, x \ln \left[\frac{P_T - \sum_{i=1}^{n} \left(P_{i,1}\right)}{P_T - \sum_{i=1}^{n} \left(P_{i,2}\right)} \right] - \left(n_{i,2} - n_{i,1}\right) \right]$$

$$N_{AVG} = \frac{VP_T}{2R} \left(\frac{1}{T_1} + \frac{1}{T_2} \right)$$

$$\left(n_{i,2} - n_{i,1}\right) = \frac{V}{(R)(T_2)} \sum_{i=1}^{n} P_{i,2} - \frac{V}{(R)(T_1)} \sum_{i=1}^{n} P_{i,1}$$

Where:

MW_{HAP}	=	average molecular weight of HAP
P_T	=	total pressure in the vessel
T_1, T_2	=	initial and final temperatures of vessel
$Pi_{,1 \text{ and } 2}$	=	partial pressure of individual HAP at T_1 and T_2
E	=	emissions of HAP vapor displaced from the vessel being heated
V	=	volume of free space in the vessel
R	=	ideal gas law constant
N_{AVG}	=	average gas space molecular volume
$ni_{,1}$ and $ni_{,2}$	=	moles of condensable in vessel headspace at T_1 and T_2.

Results of Heating Calculations for the Case Study

Emission Event	Material	Void Space Gal	T1, °C	T2, °C	T3, °C	N_{AVG}	Moles, lbmol	Mol Fraction	Partial Pressure at T1, mmHg	Partial Pressure at T2, mmHg	(ni,2-ni,1)	MW	Emissions, lb/event
Reactor Heatup	Water	5,000	25	37	10	1.67	371	0.90	21	42	0.04	18	0.09
	Methanol						41	0.10	12	23	0.02	32	0.07
	Toluene						0	0.00	0	0			

Case Study
Emission Calculations (continued)

Further, the rule specifies the use of Equations 13 and 15 (presented in the heatup worksheet) or 15 and 37 to calculate emissions from the condenser receiver outlet temperature of 10°C.

Equation 37 is presented below.

$$E = \frac{\sum_{i=1}^{n}\left(P_i\right)}{P_T - \sum_{j=1}^{m}\left(P_j\right)}\left(\Delta\eta\right)\left(MW_{HAP}\right)$$

Where:

Pj = partial pressure of condensables at receiver temperature
$\triangle\eta$ = moles of noncondensable gas displaced.

Emission Event	Material	Pa1, mmHg	Pa2, mmHg	Pa3, mmHg	Moles Noncond, Delta N	Partial Pressure at T3, mmHg	Emissions After 10°C Condenser
Reactor Heatup	Water	726	695	746	0.1308	8	0.03
	Methanol					5	0.03
	Toluene					0	0.00

Note: In these equations, three temperatures are evaluated as follows:
T1 = Initial temperature of the reactor
T2 = Temperature to which the reactor is heated
T3 = Temperature that is achieved by the condenser.

Case Study
Emission Calculations

Bubble Point Calculation:

The bubble point of a material or mixture of materials is the temperature at which the total partial pressure of the condensable materials in the system equals the pressure of the system. The bubble point is important in Subpart GGG because it determines whether a condenser is a process condenser or a control device for atmospheric vents. If the condenser cools a material from a temperature above the boiling point to a temperature that is below the boiling point, the condenser functions as a process condenser. If the material is below the bubble point, and cooling occurs, then the condenser is functioning as an air pollution control device.

Calculation:

A simple way to calculate the bubble point is to select a temperature, calculate the partial pressures of the condensable materials at that temperature, and then verify that the total partial pressure of the condensables equals or is greater than the systems pressure. For the event below, a bubble point calculation was conducted.

Emission Event	Material	Temperature, °C	Moles, lbmol	Mol Fraction	Partial Pressure, mmHg	Total Partial Pressure of Condensables	System Pressure
Strip aqueous mix	Water	98	296	0.89	621	864.40	760
	Methanol		32	0.10	235		
	Toluene		5	0.02	8		

Material Balance for Example Process

Equipment ID	Emission Event	Materials	Mass In		Loss	Mass Out	Duration, hr	Flowrate, scfm	Cycle Time, hr
			lb	gal	lb	lb			
T-1	Feed Tank Charge	Water					0.25	1.75	0.25
		Methanol	1318	200	0.36	1318			
		Toluene							
RX-1	Reactor Charge	Water	6672	800	0.03	6672	0.25	1.75	0.5
		Methanol	1318	200	0.04	1318			
		Toluene							
RX-1	Reactor Heatup	Water	6672	800	0.03	6672	6	0.02	6.5
		Methanol	1318	200	0.03	1318			
		Toluene							
RX-1	Reactor Vacuum Distillation	Water	6672	800	1.21	6671	6	6.64	12.5
		Methanol	1318	200	25.41	1292			
		Toluene	0	0	0.00	0			
EXT-1	Charge to Extraction	Water	6671	800	0.33	6670	1	2.10	13.5
		Methanol	1292	196	0.31	1292			
		Toluene	0						
EXT-1	Charge Toluene to Extraction	Water	6670	800	0.11	6670	0.25	2.89	13.75
		Methanol	1292	196	0.11	1292			
		Toluene	2486	343	0.70	2485			
EXT-1	Purge Extraction	Water	6670	800	2.40	6668	6	5.43	19.75
		Methanol	1292	196	2.62	1289			
		Toluene	2485	343	17.46	2468			
T-2	Charge Aqueous Phase to Hold Tank	Water	5334	640	0.28	5334	1	1.82	20.75
		Methanol	1031	157	0.26	1031			
		Toluene	494	68	0.03	494			
SS-1	Charge Stripper	Water	5334	640	0.28	5334	1	1.82	21.75
		Methanol	1031	156	0.26	1031			
		Toluene	494	68	0.03	494			
SS-1	Strip aqueous mix	Water	5334	640	0.04	5334	0.25	1.15	22
		Methanol	1031	156	0.04	1031			
		Toluene	494	68	0.00	494			
R-3	Stripper Receiver Charge	Water	20	2	0.05	20	0.5	0.62	22.5
		Methanol	515	78	0.35	515			
		Toluene	489	67	0.07	489			

Physical Data

Vapor Pressure					Vapor Pressures, mmHg					Molecular Weight	Density	
Compound	Antoine's Coefficients				Temperature, °C							
	a	b	c	Equation	57	37	25	20	10	lb/lbmol	sg	lb/gal
Water	18.35	3844.9	228.16	P=exp(a-b/(T+c))	130	47	24	17	9	18	1	8.34
Methanol	7.897	1474.08	229.13	P=10^(a-b/(T+c))	556	228	125	96	54	32	0.79	6.59
Toluene	6.954	1344.8	219.48	P=10^(a-b/(T+c))	123	51	28	22	12	92	0.87	7.26
Air										29		

Example Storage Tank Applicability

Tank ID	ST-1	ST-2	T-3
Material Stored	Toluene	Methanol	Organic phase prior to continuous distillation
Capacity, gallons	25,000	25,000	10,000
Maximum Bulk Storage Temp, F	96	96	135
Maximum True Vapor Pressure, mmHg	48	213	245
Operating Pressure, psig	30	atm	atm
	Tank is a pressure tank; however working losses are possible		
Subpart FFFF Applicability		Yes	Yes
Capacity, m3	95	95	38
Maximum True Vapor Pressure, kPa	6.4	28	33
>38 m3 capacity	Yes	Yes	Yes
> 6.9 kPa	No	Yes	Yes
Control required?	**No**	**Yes**	**Yes**

Example Wastewater Stream Analysis

POD Stream	SS Bottoms	Ejector Condenser R-2	Ejector Condenser R-5	Distillation Bottoms D-1
Gallons/Yr	1,432,088	9,600,000	9,600,000	365,041
Annual Average Toluene Concentration, ppmw	858	NA	100	13,676
Basis	Material balance	Analysis	Analysis	Material balance
Annual Average Methanol Concentration, ppmw	88,341	600	600	160,957
Affected Group 1 Wastewater ?	**Yes**	**No**	**No**	**Yes**

[This page intentionally left blank.]

Appendix E

- Summary of Equations Used to Calculate Uncontrolled Process Vent Emissions
- Exercises

[This page intentionally left blank.]

Table E-1. Summary of Equations Used to Calculate Uncontrolled Process Vent Emissions

Emission event	Equation	Equation number in subpart GGG	Notes
Vapor displacement	$E = \frac{(V)}{(R)(T)} \times \sum_{i=1}^{n} (P_i)(MW_i)$	Eq. 11	1. V equals displaced volume.
Purging	$E = \sum_{i=1}^{n} P_i MW_i \times \frac{(V)(t)}{(R)(T)} \times \frac{P_T}{P_T - \sum_{j=1}^{m} (P_j)}$	Eq. 12	1. Assume 25% of saturation if flow is $\geq$ 100 scfm. 2. V equals purge flow rate.
Heating	$E = MW_{HAP} \times \left[N_{AVG} \times \ln\left[\frac{P_T - \sum_{i=1}^{n} P_{i,1}}{P_T - \sum_{i=1}^{n} P_{i,2}} \right] - (n_{i,2} - n_{i,1}) \right]$	Eq. 18	1. Analytical solution. 2. Calculate ($n_{i,2} - n_{i,1}$) using Equation 20 in subpart GGG. 3. Calculate N_{avg} using Equation 19 in subpart GGG.
Depressurization	$E = \frac{V}{(R)(T)} \times \ln\left(\frac{P_1 - \sum_{i=1}^{n} (P_i)}{P_2 - \sum_{i=1}^{n} (P_i)} \right) \times \sum_{i=1}^{n} (P_i)(MW_i)$	Eq. 32	1. Analytical solution. 2. V equals free volume in the vessel being depressurized.

Emission event	Equation	Equation number in subpart GGG	Notes
Vacuum Systems	$E = \frac{(L_a)(t)}{MW_{nc}}\left[\frac{\sum_{i=1}^{n}(P_i)(MW_i)}{P_{sys} - \sum_{j=1}^{m}(P_j)}\right]$	Eq. 33	
Gas Evolution	$V = \frac{(W_g)(R)(T)}{(P_T)(MW_g)}$	Eq. 34	1. Use the evolved volume in Equation 12 to calculate HAP emissions.
Air Drying	$E = B \times \left(\frac{PS_1}{100 - PS_1} - \frac{PS_2}{100 - PS_2}\right)$	Eq. 35	
Empty Vessel Purging	$E = \left(\frac{V}{RT} \times \left(\sum_{i=1}^{n}(P_i)(MW_i)\right)\right)(1 - e^{-Ft/v})$	Eq. 36	1. The term $e^{-Ft/v}$ may be set equal to zero. This simplification results in emissions equal to the total amount in the vapor space at the start of the purge. 2. V equals the volume of the empty vessel.

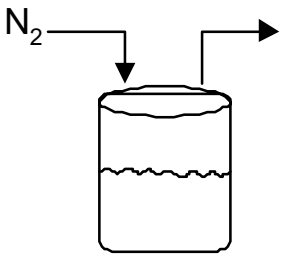
Definitions of Variables

B = mass of dry solids
E = mass of HAP emitted
F = flowrate of purge gas for empty vessel purge
L_a = total air leak rate into the system
MW_g = molecular weight of evolved gas
MW_{HAP} = average molecular weight of HAP compounds (calculate using Equation 17)
MW_i = molecular weight of individual HAP
MW_{nc} = molecular weight of noncondensable gas
N_{avg} = average gas space molar volume during the heating process (calculate using Equation 19)
$n_{i,1}$ = number of moles of condensable in the vessel headspace at T_1
$n_{i,2}$ = number of moles of condensable in the vessel headspace at T_2
P_1 = initial pressure in the vessel
P_2 = final pressure in the vessel
P_{atm} = atmospheric pressure
P_i = partial pressure of individual HAP
$P_{i,1}$ = initial partial pressure of individual HAP
$P_{i,2}$ = final partial pressure of individual HAP
P_j = partial pressure of individual condensable compound
PS_1 = weight percent of HAP in material entering dryer
PS_2 = weight percent of HAP in material exiting dryer
P_T or P_{sys} = system pressure
R = ideal gas law constant
t = time of purge or vacuum operation
T = temperature of gas in vessel (absolute)
T_1 = initial temperature of gas (absolute)
T_2 = final temperature of gas (absolute)
V = volume of gas (specific definitions given in notes column of the table
W_g = mass flow rate of gas evolution

[This page intentionally left blank.]

Workbook Exercise #1

- Calculate emissions from a 30-min nitrogen purge of a reactor containing liquid that is 50 percent methanol (i.e., the mole fraction is 0.5).
  - Data
    - Purge flow rate = 5 scfm
    - Temperature of vapor (ambient conditions): 25°C (298K)
    - VP methanol @25°C = 125 mmHg
    - System pressure = 760 mmHg
    - MW methanol: 32 lb/mole
    - R: $999 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb mole} \cdot \text{K}}$
    - Assume Raoult's law applies
    - Assume vapor pressures of organic compounds other than methanol are negligible



[This page intentionally left blank.]

Workbook Exercise #1

- Solution:

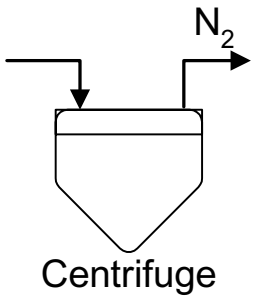
$$P_i = (X_i)(P_i^*)$$
$$= (0.5)(125)$$
$$= 62.5\,mm\,Hg$$

$$E = \sum_{i=1}^{n} P_i MW_i \frac{(V)(t)}{(R)(T)}\left[\frac{P_T}{P_T - \sum P_j}\right] \qquad \text{(Eq. 12)}$$

$$E = \frac{(62.5\,mmHg)(32\,lb/lbmole)(5\,ft^3/\min)(30\,\min)}{\left(999\,\frac{mmHg\cdot ft^3}{lbmole\cdot K}\right)(298\,K)}\left[\frac{760}{760 - 62.5}\right]$$
$$= 1.1\,lb/event$$

[This page intentionally left blank.]

Workbook Exercise #2



- Objective: Calculate uncontrolled HAP emissions for N_2 purge of a centrifuge (CENT-1)
- Data
  - Flowrate of N_2: 500 scfm for 5 minutes
  - Temperature of vapor space: 37°C
  - Composition:
    - 26 lbs H_2O
    - 81 lbs MeOH
    - 199 lbs $CHCl_3$
    - 306 lbs total

[This page intentionally left blank.]

Workbook Exercise #2 (cont.)

Calculation procedure:

Step 1: Calculate x_i (mole fraction) and P_i (partial pressure) of condensables. Vapor pressure P* of materials at 37°C. The vapor pressures and molecular weights are found in the data table for the case study (see Appendix C).

Material	Mass, lb	MW	lb moles	x_i	Vapor pressure P*, mmHg	Partial pressure P_i, mmHg	25% saturation P_i, mmHg
H_2O	26	18	1.44	.26	42	12	3
MeOH	81	32	2.5	.45	228	102	25
$CHCl_3$	199	119.4	1.7	.30	320	94	24
		Total	5.6			208	52

Note that because the flowrate is >100 scfm, the emission stream must be assumed to be only 25 percent saturated.

[This page intentionally left blank.]

Workbook Exercise #2 (cont.)

Step 2: Correct flowrate for non-standard conditions.

V = 500 scfm @standard conditions: 68°F (20°C) and 1 atm

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Since $P_1 = P_2$, the equation to calculate the flowrate at actual conditions simplifies to:

$$V_2 = V_1\left(\frac{T_2}{T_1}\right)$$

$$\left(500\frac{ft^3}{min}\right)\left(\frac{273+37°C}{273+20°C}\right) = 529\frac{ft^3}{min}$$

[This page intentionally left blank.]

Workbook Exercise #2 (cont.)

Step 3: Calculate uncontrolled emissions for the event.

$$E = \sum P_i MW_i \frac{(V)(t)}{(R)(T)} \left[\frac{P_T}{(P_T - \sum P_j)} \right]$$

$$E_{MeOH} = \frac{(25\,\text{mmHg})(32\,\text{lb/lbmol})(529\,\text{ft}^3/\text{min})(5\,\text{minutes})}{\left(999\,\frac{\text{mmHg ft}^3}{\text{lbmol K}}\right)(310\,\text{K})} \left[\frac{760}{(760-52)} \right]$$

$$E_{MeOH} = 7.4\,\text{lb MeOH}$$

$$E_{CHCl_3} = \frac{(24\,\text{mmHg})(119.4\,\text{lb/mol})(529\,\text{ft}^3/\text{min})(5\,\text{minutes})}{\left(999\,\frac{\text{mmHg ft}^3}{\text{lbmol K}}\right)(310\,\text{K})} \left[\frac{760}{(760-52)} \right]$$

$$= 25.5\,\text{lb}\,CHCl_3$$

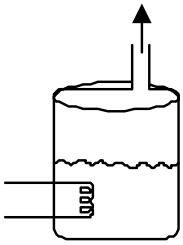
E = (7.4 lb MeOH + 25.5 lb $CHCl_3$)

= 33 lb HAP emitted during 5-minute purge event

[This page intentionally left blank.]

Workbook Exercise #3

- Objective: Calculate emissions from heating a 1,250 gal reactor that contains 750 gal of a toluene solution from 20°C to 70°C.
  - Data



    - Initial temperature (T_1) = 20°C (293 K)
    - Final temperature (T_2) = 70°C (343 K)
    - Reactor vapor space = 500 gallons
    - Toluene MW = 92 lb/lbmole
    - 7.48 gal/ft^3
    - R = $999 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb mole} \cdot \text{K}}$
    - System pressure = 760 mmHg
    - Assume toluene is the only condensable compound

[This page intentionally left blank.]

Workbook Exercise #3 (cont.)

- Solution: Use equations 18, 19, and 20 in §63.1257 of subpart GGG.

$$E = MW_{HAP}\left(N_{AVG}\ell n\left(\frac{P_T - \sum_{i=1}^{n} P_{i,1}}{P_T - \sum_{i=1}^{n} P_{i,2}} \right) - \left(n_{i,2} - n_{i,1} \right) \right) \qquad \text{(Eq. 18)}$$

$$N_{AVG} = \frac{VP_T}{2R}\left(\frac{1}{T_1} + \frac{1}{T_2} \right) \qquad \text{(Eq. 19)}$$

$$n_{i,2} - n_{i,1} = \frac{P_{i,2}V}{RT_2} - \frac{P_{i,1}V}{RT_1} \qquad \text{(Eq. 20)}$$

Step 1: Calculate N_{AVG}

$$N_{AVG} = \frac{\left(500gal\right)\left(\frac{ft^3}{7.48gal} \right)\left(760mmHg\right)}{(2)\left(999\frac{mmHg \cdot ft^3}{lbmole \cdot K} \right)}\left(\frac{1}{293K} + \frac{1}{343K} \right)$$

$$= 0.161lbmole$$

[This page intentionally left blank.]

Workbook Exercise #3 (cont.)

Step 2: Calculate toluene partial pressure. One way is to use the Antoine equation as follows (with coefficients obtained from Lange's Handbook of Chemistry):

$$\log P = A - \frac{B}{T(^\circ C) + C}$$

$$\log P_{toluene,20^\circ C} = 6.955 - \frac{1344.8}{20 + 219.48}$$

$$= 1.339$$

$$P_{toluene,20^\circ C} = 21.85 mmHg$$

Similarly,

$$\log P_{toluene,70^\circ C} = 6.955 - \frac{1344.8}{70 + 219.48}$$

$$= 2.309$$

$$P_{toluene,70^\circ C} = 203.9 mmHg$$

[This page intentionally left blank.]

Workbook Exercise #3 (cont.)

Step 3: Calculate $n_{i,2} - n_{i,1}$

$$n_{i,2} - n_{i,1} = \frac{(500gal)(ft^3/7.48gal)}{\left(999\frac{mmHg \cdot ft^3}{lbmole \cdot K}\right)}\left(\frac{203.9mmHg}{343K} - \frac{21.85mmHg}{293K}\right)$$

$$= 0.0348lbmole$$

Step 4: Calculate toluene emissions

$$E = (92lb/lbmole)\left((0.161lbmole)\ell n\left(\frac{760 - 21.85}{760 - 203.9}\right) - (0.0348lbmole)\right)$$

$$= 0.99lb\ toluene\ emitted\ during\ heatup$$

[This page intentionally left blank.]

Appendix F

- Data for Monitoring Example in Section 7
- Exercise to Determine Ongoing Compliance Status

[This page intentionally left blank.]

Data for Monitoring Examples

Thermal Incinerator
Temperature set during the performance test: 1760°F

Time	Temperature Measured, °F	Hourly Average
12:00 AM	1740	1754
12:15 AM	1760	
12:30 AM	1760	
12:45 AM	1754	
1:00 AM	1750	1731
1:15 AM	1730	
1:30 AM	1720	
1:45 AM	1725	
2:00 AM	1730	1743
2:15 AM	1743	
2:30 AM	1750	
2:45 AM	1750	
3:00 AM	1752	1753
3:15 AM	1752	
3:30 AM	1753	
3:45 AM	1755	
4:00 AM	1760	1763
4:15 AM	1762	
4:30 AM	1765	
4:45 AM	1766	
5:00 AM	1768	1767
5:15 AM	1768	
5:30 AM	1768	
5:45 AM	1765	

Data for Monitoring Examples (continued)

Time	Temperature Measured, °F	Hourly Average
6:00 AM	1764	1763
6:15 AM	1762	
6:30 AM	1762	
6:45 AM	1765	
7:00 AM	1766	1768
7:15 AM	1768	
7:30 AM	1768	
7:45 AM	1769	
8:00 AM	1770	1772
8:15 AM	1771	
8:30 AM	1772	
8:45 AM	1775	
9:00 AM	1777	1759
9:15 AM	1740	
9:30 AM	1760	
9:45 AM	1760	
10:00 AM	1754	1739
10:15 AM	1750	
10:30 AM	1730	
10:45 AM	1720	
11:00 AM	1725	1737
11:15 AM	1730	
11:30 AM	1743	
11:45 AM	1750	
12:00 PM	1750	1757
12:15 PM	1777	
12:30 PM	1740	
12:45 PM	1760	

Data for Monitoring Examples (continued)

Time	Temperature Measured, °F	Hourly Average
1:00 PM	1760	1749
1:15 PM	1754	
1:30 PM	1750	
1:45 PM	1730	
2:00 PM	1720	1730
2:15 PM	1725	
2:30 PM	1730	
2:45 PM	1743	
3:00 PM	1750	1764
3:15 PM	1750	
3:30 PM	1777	
3:45 PM	1777	
4:00 PM	1740	1754
4:15 PM	1760	
4:30 PM	1760	
4:45 PM	1754	
5:00 PM	1750	1731
5:15 PM	1730	
5:30 PM	1720	
5:45 PM	1725	
6:00 PM	1730	1743
6:15 PM	1743	
6:30 PM	1750	
6:45 PM	1750	
7:00 PM	1777	1777
7:15 PM		
7:30 PM		
7:45 PM	1777	

Data for Monitoring Examples (continued)

Time	Temperature Measured, °F	Hourly Average
8:00 PM		1777
8:15 PM	1777	
8:30 PM	1777	
8:45 PM		
9:00 PM	1777	1770
9:15 PM	1777	
9:30 PM	1777	
9:45 PM	1750	
10:00 PM	1750	1761
10:15 PM	1777	
10:30 PM	1777	
10:45 PM	1740	
11:00 PM	1760	1756
11:15 PM	1760	
11:30 PM	1754	
11:45 PM	1750	

Results:

24-hour average from raw data: 1754°F
24-hour average from hourly averages: 1755°F

Questions and Answers

Q. *Is the thermal incinerator in compliance with the operating limit?*

A. No. The daily average is less than the 1760°F operating limit.

Q. *Are the data availability requirements met (is there sufficient valid data)?*

A. Yes. There are 2 hours during the day for which data are not available for each 15-minute period (both of these 2 hours have measurements for two of the 15-minute periods). For CPMS and a control device that operates at least 4 hr/d, the MON requires data for each of the 15-minute periods in an hour to have a valid hour of data. In addition, the MON requires valid data for at least 75 percent of the hours in the day. The source in our example easily meets this requirement (22/24 = 91 percent).

Q. *What recordkeeping and reporting would be required for the day in this example?*

A. At a minimum, a record of the daily average is required. The MON references subpart SS, which generally requires records of the 15-minute (or more frequent) measurements as well. However, subpart SS also allows a source to retain only the daily average, provided several requirements are met. One of the requirements is that the equipment must keep a running average, calculated hourly, of values for at least the preceding 6 hours, and a record is required anytime this value is outside the operating limit.

In addition, the compliance report must include a variety of information related to the deviation (e.g., the date, the daily average, a description of the process/CMS, HAP in the emission stream, date of the latest CMS certification or audit, and the operating log for the day). Information from this deviation also would be combined with information for other deviations to generate summary statistics of the total duration of deviations and their causes during the reporting period.

 [This page intentionally left blank.]

Exercise

Suppose the data in the preceding table are for an incinerator that is used to control emissions from a batch process that operates from 7:00 p.m. to 11:00 p.m. on the day for which the data apply. Also assume the owner or operator has elected to demonstrate compliance by averaging over an operating block consisting of the entire batch cycle, and the operating limit is still 1760°F.

Question: *Is the source in compliance with its operating limit?*

[This page intentionally left blank.]

Answer to Exercise

Yes. The block average is okay (1769°F is greater than 1760°F). However, for CPMS, data are required for all of the 15-minute periods in an hour to have a valid hour of data. In addition, for a control that operates at least 4 hours per day, valid data must be available for at least 75 percent of the hours in a day. Since the source in this exercise has valid data for only 2 of the 4 hours of control operation (50 percent), they have a deviation from the data availability requirement.

[This page intentionally left blank.]

Appendix G

- Acronyms
- Definitions
- Applicability Materials

 [This page intentionally left blank.]

Acronyms

AMR	Actual mass removal
APCD	Air pollution control device
BOD	Biological oxygen demand
BPV	Batch process vent
BR	Bottoms receiver
CAA	Clean Air Act
CAR	Consolidated Federal Air Rule
CCCD	Centralized combustion control device
CEMS	Continuous emissions monitoring system
Cl_2	Chlorine
CMS	Continuous monitoring system
CPMS	Continuous parameter monitoring system
CPV	Continuous process vent
CVS	Closed-vent system
DE	Design evaluation
DOT	Department of Transportation
EFR	External floating roof
EI	Emission inventory
EIQ	Emission inventory questionnaire
Fr	Fraction removed (values in Table 9 to subpart G)
HAP	Hazardous air pollutant
HCl	Hydrogen chloride
HF	Hydrogen fluoride
HON	Hazardous Organic NESHAP
IFR	Internal floating roof
LDAR	Leak detection and repair program
MACT	Maximum achievable control technology
MCPU	Miscellaneous organic chemical manufacturing process unit
MTVP	Maximum true vapor pressure
NAICS	North American Industrial Classification System
NOCS	Notification of compliance status
OLD	Organic Liquid Distribution (MACT subpart EEEE)
o/o	Owner or operator
P&ID	Process and instrumentation diagram
PM HAP	Particulate matter HAP
PMPU	Pharmaceutical manufacturing process unit
POD	Point of determination
PRM	Planned routine maintenance
PRV	Pressure relief valve
PSHAP	Partially soluble HAP (listed in Table 8 to subpart FFFF)
PT	Performance test
PTE	Potential to emit
PUG	Process unit group
PV	Process vent

Acronyms (continued)

QA/QC	Quality assurance/quality control
QIP	Quality improvement program
RCRA	Resource Conservation and Recovery Act
RMR	Required mass removal
SCV	Surge control vessel
SHAP	Soluble HAP (listed in Table 9 to subpart FFFF)
SIC	Standard Industrial Classification
SOCMI	Synthetic organic chemical manufacturing industry
SSM	Startup, shutdown, and malfunction
ST	Storage tank
TOC	Total organic compounds
TRE	Total resource effectiveness
TSS	Total suspended solids
VOC	Volatile organic compounds
WMU	Waste management unit
WW	Wastewater

325 Chemical Manufacturing

1997 NAICS	1997 NAICS U.S. Description	Codes		1987 SIC	1987 U.S. SIC Description
325	Chemical Manufacturing				
3251	Basic Chemical Manufacturing				
32511	Petrochemical Manufacturing		N	*2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments (aromatics)
				*2869	Industrial Organic Chemicals, NEC (aliphatics)
32512	Industrial Gas Manufacturing		R	2813	Industrial Gases
				*2869	Industrial Organic Chemicals, NEC (fluorocarbon gases)
32513	Synthetic Dye and Pigment Manufacturing				
325131	Inorganic Dye and Pigment Manufacturing	u	N	*2816	Inorganic Pigments (except bone and lamp black)
				*2819	Industrial Inorganic Chemicals, NEC (inorganic dyes)
325132	Synthetic Organic Dye and Pigment Manufacturing	u	N	*2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments (organic dyes and pigments)
32518	Other Basic Inorganic Chemical Manufacturing				
325181	Alkalies and Chlorine Manufacturing	c	E	2812	Alkalies and Chlorine
325182	Carbon Black Manufacturing	u	R	*2816	Inorganic pigments (bone and lamp black)
				2895	Carbon Black
325188	All Other Basic Inorganic Chemical Manufacturing	u	R	*2819	Industrial Inorganic Chemicals, NEC (except activated carbon and charcoal, alumina, and inorganic industrial dyes)
				*2869	Industrial Organic Chemicals, NEC (carbon bisulfide)
32519	Other Basic Organic Chemical Manufacturing				
325191	Gum and Wood Chemical Manufacturing	u	E	2861	Gum and Wood Chemicals
325192	Cyclic Crude and Intermediate Manufacturing	u	R	*2865	Cyclic Organic Crudes and Intermediates and Organic Dyes and Pigments (except aromatics and organic dyes and pigments)
325193	Ethyl Alcohol Manufacturing	u	N	*2869	Industrial Organic Chemicals (ethyl alcohol)
325199	All Other Basic Organic Chemical Manufacturing	u	R	*2869	Industrial Organic Chemicals, NEC (except aliphatics, carbon bisulfide, ethyl alcohol, and fluorocarbon gases)
				*2899	Chemical and Chemical Preparations, NEC (fatty acids)

3252	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing				
32521	Resin and Synthetic Rubber Manufacturing				
325211	Plastics Material and Resin Manufacturing	u	E	2821	Plastics Materials, Synthetic and Resins, and Nonvulcanizable Elastomers
325212	Synthetic Rubber Manufacturing	u	E	2822	Synthetic Rubber
32522	Artificial and Synthetic Fibers and Filaments Manufacturing				
325221	Cellulosic Organic Fiber Manufacturing	u	E	2823	Cellulosic Manmade Fibers
325222	Noncellulosic Organic Fiber Manufacturing	u	E	2824	Manmade Organic Fibers, Except Cellulosic
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing				
32531	Fertilizer Manufacturing				
325311	Nitrogenous Fertilizer Manufacturing	u	E	2873	Nitrogenous Fertilizers
325312	Phosphatic Fertilizer Manufacturing	u	E	2874	Phosphatic Fertilizers
325314	Fertilizer (Mixing Only) Manufacturing	c	E	2875	Fertilizers, Mixing Only
32532	Pesticide and Other Agricultural Chemical Manufacturing		E	2879	Pesticides and Agricultural Chemicals, NEC
3254	Pharmaceutical and Medicine Manufacturing				
32541	Pharmaceutical and Medicine Manufacturing				
325411	Medicinal and Botanical Manufacturing	u	E	2833	Medicinal Chemicals and Botanical Products
325412	Pharmaceutical Preparation Manufacturing	u	R	2834	Pharmaceutical Preparations
				*2835	In-Vitro and In-Vivo Diagnostic Substances (except in-vitro diagnostic)
325413	In-Vitro Diagnostic Substance Manufacturing	u	N	*2835	In-Vitro and In-Vivo Diagnostic Substances (in-vitro diagnostic substances)
325414	Biological Product (except Diagnostic) Manufacturing	u	E	2836	Biological Products, Except Diagnostic Substance
3255	Paint, Coating, and Adhesive Manufacturing				
32551	Paint and Coating Manufacturing		R	2851	Paints, Varnishes, Lacquers, Enamels and Allied Products
				*2899	Chemicals and Chemical Preparations, NEC (frit)
32552	Adhesive Manufacturing		E	2891	Adhesives and Sealants
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing				

32561	Soap and Cleaning Compound Manufacturing				
325611	Soap and Other Detergent Manufacturing	u	R	2841	Soaps and Other Detergents, Except Specialty Cleaners
				*2844	Toilet Preparations (toothpaste)
325612	Polish and Other Sanitation Good Manufacturing	u	E	2842	Specialty Cleaning, Polishing, and Sanitary Preparations
325613	Surface Active Agent Manufacturing	u	E	2843	Surface Active Agents, Finishing Agents, Sulfonated Oils, and Assistants
32562	Toilet Preparation Manufacturing		R	*2844	Perfumes, Cosmetics, and Other Toilet Preparations (except toothpaste)
3259	Other Chemical Product and Preparation Manufacturing				
32591	Printing Ink Manufacturing		E	2893	Printing Ink
32592	Explosives Manufacturing		E	2892	Explosives
32599	All Other Chemical Product and Preparation Manufacturing				
325991	Custom Compounding of Purchased Resins	c	E	3087	Custom Compounding of Purchased Plastics Resin
325992	Photographic Film, Paper, Plate, and Chemical Manufacturing	u	N	*3861	Photographic Equipment and Supplies (photographic films, paper, plates and chemicals)
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	u	R	*2819	Industrial Inorganic Chemicals, NEC (activated carbon and charcoal)
				*2899	Chemicals and Chemical Preparations, NEC (except frit and table salt)
				*3952	Lead Pencils and Art Goods (drawing inks and india ink)
				*3999	Manufacturing Industries, NEC (matches)
				*7389	Business Services, NEC (aerosol packaging)

[This page intentionally left blank.]

Miscellaneous organic chemical manufacturing process means all equipment which collectively function to produce a product or isolated intermediate that are materials described in §63.2435(b). For the purposes of this subpart, process includes any, all or a combination of reaction, recovery, separation, purification, or other activity, operation, manufacture, or treatment which are used to produce a product or isolated intermediate. A process is also defined by the following:

(1) Routine cleaning operations conducted as part of batch operations are considered part of the process;

(2) Each nondedicated solvent recovery operation is considered a single process;

(3) Each nondedicated formulation operation is considered a single process that is used to formulate numerous materials and/or products;

(4) Quality assurance/quality control laboratories are not considered part of any process; and

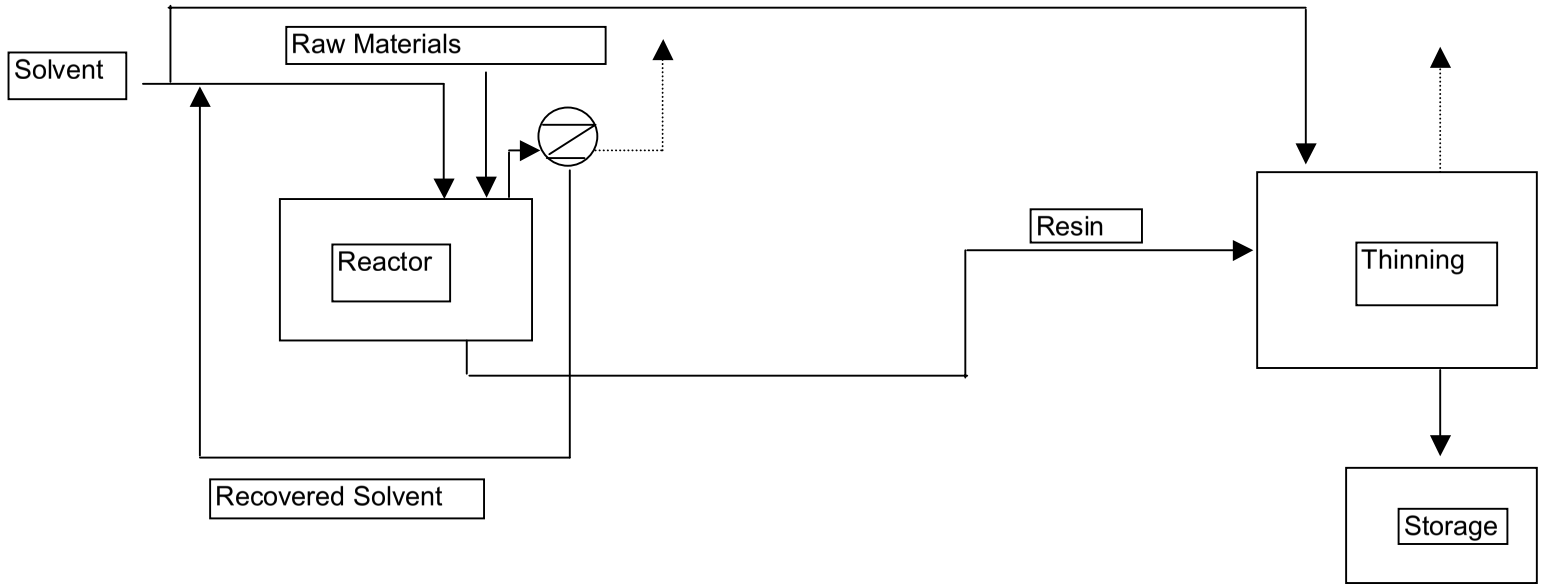
(5) Ancillary activities are not considered a process or part of any process.

 [This page intentionally left blank.]

Family of materials means a grouping of materials with the same basic composition or the same basic end use or functionality produced using the same basic feedstocks with essentially identical HAP emission profiles (primary constituent and relative magnitude on a pound per product basis) and manufacturing equipment configuration. Examples of families of materials include multiple grades of the same product or different variations of a product (e.g., blue, black, and red resins).

[This page intentionally left blank.]

Example- Family of Materials
Unsaturated Polyester Resins



Product	Raw Materials	Emissions Events	HAP	lb/batch	Control
Polyester A	Ethylene Glycol	Charge Reactor	Ethylene Glycol	0.0003	Condenser
	Phthalic Anhydride		Phthalic Anhydride	0.0005	Condenser
			Styrene	20	Condenser
	Styrene	Solvent Addition	Styrene	30	None
Polyester B	Ethylene Glycol	Charge Reactor	Ethylene Glycol	0.0003	Condenser
	Maleic Anhydride		Maleic Anhydride	0.0005	Condenser
			Styrene	20	Condenser
	Styrene	Solvent Addition	Styrene	30	None
Polyester C	Propylene Glycol	Charge Reactor	Propylene Glycol	0.0003	Condenser
	Maleic Anhydride		Maleic Anhydride	0.0005	Condenser
			Styrene	20	Condenser
	Styrene	Solvent Addition	Styrene	30	None
Polyester D	Propylene Glycol	Charge Reactor	Propylene Glycol	0.0003	Condenser
	Phthalic Anhydride		Phthalic Anhydride	0.0005	Condenser
			Xylene	30	Condenser
	Xylene	Solvent Addition	Xylene	40	None

[This page intentionally left blank.]

Storage tank means a tank or other vessel that is used to store liquids that contain organic HAP and/or hydrogen halide and halogen HAP and that has been assigned to an MCPU according to the procedures in §63.2435(d). The following are not considered storage tanks for the purposes of this subpart:

(1) Vessels permanently attached to motor vehicles such as trucks, railcars, barges, or ships;

(2) Pressure vessels designed to operate in excess of 204.9 kilopascals and without emissions to the atmosphere;

(3) Vessels storing organic liquids that contain HAP only as impurities;

(4) Wastewater storage tanks;

(5) Bottoms receivers;

(6) Surge control vessels; and

(7) Process tanks.

[This page intentionally left blank.]

Appendix H

- Presenters' Biographical Sketches

[This page intentionally left blank.]

B S , . ., has more than 15 years of experience in air quality consulting. She holds a B.S. in Chemical Engineering from the University of Texas at Austin. Prior to starting her own consulting firm (North State Engineering, Inc. [NSE]), she was employed as a senior environmental engineer for Midwest Research Institute (MRI), where she provided technical assistance to various divisions of EPA's Office of Air Quality Planning and Standards (OAQPS). She participated in the development of guidance and federal air standards such as national emission standards for hazardous air pollutants (NESHAP) for Pharmaceuticals Production. As principal of North State Engineering, she continues to consult to EPA in standards development projects. She is currently a project assistant to the development of the Miscellaneous Organic NESHAP (MON). She also provides industrial clients with air quality consulting services such as compliance auditing, Title V permit development, regulatory applicability studies, emission inventories, and SARA reports. She has written numerous Title V permit applications in several states, including Illinois, Texas, and North Carolina and continues to assist in the development of implementation plans associated with these issued permits. Ms. Shine is a registered professional engineer in Texas and North Carolina.

D is a Research Chemical Engineer III with RTI International in Research Triangle Park, North Carolina. He has more than 15 years experience providing technical assistance to EPA in the development of National Emission Standards for Hazardous Air Pollutants (NESHAP) and other regulatory development projects. Recent projects have involved NESHAP for Pharmaceuticals Production, Pesticide Active Ingredient Production, and Miscellaneous Organic Chemical Manufacturing. He holds a B.S. in Chemical Engineering from the University of New Hampshire and an M.S. in Chemical Engineering from the University of Kentucky.