DRAFT ENGINEERING EVALUATION FOR APP # 27299
ALTA DEVICES, INC.

545 OAKMEAD PARKWAY SUNNYVALE CA 94085
PLANT # 20677

BACKGROUND

Alta Devices, Inc., a photovoltaics facility located at 545 Oakmead Parkway Sunnyvale CA 94085, has applied for a change of permit conditions for their existing cleanroom (S-2); they will be increasing the number of chemical vapor deposition (CVD) chambers, increasing solvent usage, adding additional equipment and printing inks. Currently Alta Devices has 4 CVD tools (a total of 6 chambers) and they will be expanding operations to include 8 additional CVD tools. Each additional tool is accompanied by its own abatement device. They are also applying for 4 additional catastrophic release abatement devices for emergencies. All abatement devices are over 99.99% efficient according to manufacturer specifications. Alta Devices has a research lab (S-3) that has been evaluated by the District in a previous application and determined to be exempt. This application also includes changes to the capacity of the wet chemical stations in their research lab.

S-2 Cleanroom (Fabrication Area #1)

Fabrication Area (or fab area) #1 consists of 2 separate areas within the facility. Per Regulation 2-1-231, these areas can be grouped into a single fab area and all equipment can also be grouped within the same fab area. The following modifications are proposed for fab area #1:

- Increase in the number of CVD tools from 4 to 12. The new tools, each of which has only 1 chamber, are named R6 #1, R6 #2, R6 #3, R6 #4, R6 #5, R6 #6, K475 and Hercules. The amount of process gases, cleaning gas and dopants are being increased to accommodate for the expansion in the facilities operations. The proposed aggregate chemical throughput amounts for the CVD tools are as follows:

Chemical	Use	Max. Throughput (pounds)
Arsine	Process gas	60,000
Phosphine	Process gas	15,000
Chlorine	Chamber clean gas	2,500
Trimethyl Gallium	Process gas	5,000
Trimethyl Indium	Process gas	150
Trimethyl Aluminum	Process gas	150
Carbon Tetrabromide	Dopant	150
Diethyl Zinc	Dopant	20
Disilane	Dopant	22

Note: Hydrogen and/or Nitrogen will be used as carrier gases to deliver these chemicals

- Increase in the usage amount for Acetone for wipe cleaning from 300 gallons to 500 gallons annually.

- Addition of the following pieces of equipment in cleanroom S-2

  i. Baccini Automated Screen Printer, Make and Model: Applied Materials PRN-101

  The following chemicals will be used for printing and coloring in this screen printer:

Chemical	Max. Throughput (gal/yr)
UV Plating Resist Blue (DXT – 2619)	50
UV Plating Resist Blue (DXT – 2620)	50
Resist Ink Scr Black (ETSA – 1150)	50
Resist Ink Scr Clear (CXT – 0698)	50

Note: Although these chemicals are called resists they are not used as photoresists but as coatings only.

  ii. Matrix Bonder, Make and Model: Komax Series C Bonder

  iii. Matrix Bonder High-Volume Matrix, Make and Model: Komax Large-format Bonder

Abatement Devices: General Use and Catastrophic Release

Alta Devices intends to install the following 8 general use dry scrubbers which will abate the exhaust gases from the 8 new CVD chambers that they will be installing in the cleanroom (S-2). These scrubbers are over 99.99% efficient and are capable of removing all process gases and chlorine, as well as metal organics. After going through the abatement devices, the exhaust gases will collectively emit to ambient air through emission point P-4.

A-6 Europa Dry Scrubber, Jupiter Scientific 2+

A-7 Europa Dry Scrubber, Jupiter Scientific 2+

A-8 Europa Dry Scrubber, Jupiter Scientific 2+

A-9 Europa Dry Scrubber, Jupiter Scientific 2+

A-10 Europa Dry Scrubber, Jupiter Scientific 2+

A-11 Europa Dry Scrubber, Jupiter Scientific 2+

A-12 Europa Dry Scrubber, Jupiter Scientific 2+

A-17 Europa Dry Scrubber, Jupiter Scientific 2+

In addition to the above general use abatement devices, 4 catastrophic release dry scrubber abatement devices are also included in the permit application. These devices are already in use and will be used in the event of an emergency. All of these devices release to ambient air through emission point P-5. Although these abatement devices are called scrubbers, they are not wet scrubbers; they utilize absorbent media.

A-13 Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+

A-14 Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+

A-15 Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+

A-16 Olympus Dry Scrubber catastrophic release of Chlorine, Jupiter Scientific 2+

S-3 Photovoltaic (Semiconductor) Fab Area, ELO Lab (EXEMPT source)

- Increase capacity of wet chemical stations from 350 gals to 2260 gals (1910 gals increase). Increase throughput amounts of the following materials.

Chemical	Max. Throughput (gal/yr)
49% Hydrofluoric acid	20,000
28% Ammonium hydroxide	11,000
10% Sulfuric acid	12,750
10% Phosphoric acid	12,500
10% Potassium hydroxide	500
10% Hydrochloric acid	40

This evaluation report will estimate the criteria pollutant and toxic emissions associated with the operation of the above-mentioned sources and will discuss the compliance of these operations with applicable rules and regulations. S-2 and A-6 to A-17 are subject to Permit Condition No. 26244. The entire facility is subject to Condition No. 26246.

EMISSIONS CALCULATIONS

The operations in the cleanroom (S-2) result in the emission of toxic air contaminants (TACs) and precursor organic compounds (POCs). Arsine, Phosphine and Chlorine are TACs (Table 2-5-1). They do not contribute to criteria pollutant emissions and thus their emissions are discussed in the toxic risk screening section below. POCs are potentially emitted from three different sources – wipe cleaning, printing materials and dopants. The POC emissions from each of these sources are discussed separately in the following sections. Although a number of metal organics and disilane are also used in fab area #1, these do not contribute to POC or toxic emissions.

For wipe cleaning, it is assumed that 100% of the POCs are emitted (Table 1). Acetone and Isopropyl alcohol (IPA) are used for wipe cleaning but only the amount of acetone is being increased in this application. Acetone does not contribute to POC emissions because it is classified as a non-precursor organic compound (NPOC).

Table 1: POC emissions increase from wipe cleaning

Chemical	Annual Throughput	Density	POC?	POC Emissions (100% emitted)	
	[gal/year]	[lbs/gal]		[lbs/year]	[lbs/day]
Acetone	200	6.60	No	0.00	0.00

POC emission from the printing inks and colorants are presented in Table 2. Four types of printing inks and colorants are used in S-2. It is assumed that 100% of the VOC content in the inks and colorants is emitted based on the BAAQMD Permit Handbook guidelines for coatings.

Table 2: POC emissions increase from printer inks

Product name and code	Annual Throughput	VOC Content	Density of product	POC Emissions (100% of VOC emitted)	
	[gals/yr]	%	[lbs/gal]	[lbs/year]	[lbs/day]
UV Plating Resist Blue (DXT - 2619)	50	45.4	9.608	218	0.614
UV Plating Resist Blue (DXT - 2620)	50	44.25	9.676	214	0.603
Resist Ink Scr Black (ETSA - 1150)	50	47.72	9.588	229	0.644
Resist Ink Scr Clear (CXT - 0698)	50	52.31	8.894	233	0.655

Process gases and dopants have the potential to emit POCs. Metal organics (Trimethyl Gallium (TMG), Trimethyl Indium (TMI), Trimethyl Aluminum (TMA), and Diethyl Zinc (DEZ)) are used as process gases and dopants for manufacturing operations. Carbon Tetrabromide (CBr_4) is used as a dopant. Although organic compounds are produced during the use of these dopants, they do not contribute towards POC emissions because as they are being used in the chambers the metal organics completely disintegrate into the metal and methane/ethane. A majority of the metal (the exact amount is proprietary) is deposited onto the substrate while the remainder is deposited in the chamber, vacuum pump and exhaust pipes. When the CVD chamber is cleaned using chlorine, it reacts with the metal to form volatile metal chlorides which are subsequently removed by the abatement devices. Since ethane and methane are not considered to be POCs (Per 2-1-206, due to their negligible photochemical reactivity), emissions from the dopants are zero. A detailed description of the process is provided below.

If heated above 120°C (248°F), TMG undergoes exothermic decomposition with the evolution of flammable gas. Other organometallic dopants such as TMI, TMA and DEZ follow decomposition mechanisms similar to the decomposition of TMG. As with other main group organometallics, the decomposition mechanisms are complex but the major reactions involved in TMG decomposition in inert gases are:

$$(CH_3)_3Ga \rightarrow CH_3 + (CH_3)_2Ga \text{ and } CH_3 + (CH_3)_3Ga \rightarrow CH_4 + CH_2Ga(CH_3)_2$$

At elevated temperatures a chain reaction takes place with hydrogen:

$$CH_3 + H_2 \rightarrow CH_4 + H \text{ and } H + (CH_3)_3Ga \rightarrow CH_4 + CH_3^{\bullet} + CH_3Ga$$

Ultimately, most of the metallic gallium is incorporated into the substrate and the exhaust gas contains unreacted TMG, partially decomposed TMG, methane, ethane as well as some ethylene. The methyl radical exists in dilute gases, but at higher concentrations it readily dimerizes to ethylene. The relative amount of methane (CH_4) increases and the amount of ethylene, C_2H_4, decreases with an increase in hydrogen concentration relative to inert gases such as nitrogen. At elevated temperatures ethylene reacts with hydrogen to form ethane. Thus, the decomposition of TMG forms mostly methane and lesser amounts of ethylene and ethane. Unreacted TMG reacts with the oxidizers in the abatement device or combusts in air to form gallium oxide, carbon dioxide and water.

Other organometallic compounds react similarly to form their respective oxides, methane, and ethane. TMA decomposes on heated silicon and gallium arsenide (GaAs) substrates, following decomposition mechanisms similar to those of TMG. The chemical is initially absorbed onto the substrate as a dimer at low temperatures. Upon heating to temperatures above approximately 125 °C the chemical decomposes liberating methane. Intermediate metal alkyls react to eventually form methane as the temperature increases. At temperatures above ~ 420 °C some of the carbon in the source chemical forms silicon carbide.

TMI decomposes homogeneously in hydrogen to form methane and decomposes heterogeneously to form intermediate free radicals and dimers. TMI undergoes a methyl exchange reaction on GaAs to form gallium alkyl. Upon heating above room temperature, a Ga–alkyl desorbs, followed by desorption of the methyl radical at higher temperatures. The Ga–alkyl has the same cracking pattern as observed for TMG decomposition. The exhaust will contain unreacted TMI, and some indium and gallium alkyls that are eventually consumed in the abatement device.

DEZ decomposes at elevated temperatures to form ethane instead of methane. Similar to the other organometallics unreacted DEZ is fully decomposed in the abatement device. CBr_4, used as a dopant, does not cause POC emissions either. Details of the reaction process are proprietary.

In conclusion, total POC emissions from the various sources in S-2 are presented in Table 3.

Table 3: Total POC Emissions

	POC Emissions		
	[lbs/day]	[lbs/year]	[TPY]
POC (wipe cleaning)	0.00	0	0.000
POC (printing and colorant inks)	2.52	894	0.447
POC (dopants)	0.00	0	0
Total POC Emissions	2.52	894	0.447

PLANT CUMULATIVE INCREASE

Alta Devices Inc. is an existing facility and already has some emissions. Cumulative increases in emissions are reported in Table 4.

Table 4: Cumulative Emissions Increase

Pollutant	Existing Emissions	New Emissions	Total Emissions
	[TPY]	[TPY]	[TPY]
POC	1.497	0.447	1.944
NO_x	0.181	0.000	0.181
SO_x	0.000	0.000	0.000
PM_{10}	0.005	0.000	0.005
CO	0.025	0.000	0.025

TOXIC RISK SCREENING

Toxics are emitted from the process gases used in the CVD chambers as well as the printing inks and colorants. Arsine, phosphine and chlorine are abated by Europa dry scrubbers as well as from the catastrophic release scrubbers in case of emergencies. Emissions from the catastrophic release devices are zero since catastrophic releases are rare events.

Final emissions from the general use scrubbers are presented in Table 5 below. Emissions for phosphine and arsine are based on a maximum concentration of 25 ppb at the outlet of the abatement devices except for the abatement devices linked to 2 of the CVD tools (Crius II) where the maximum outlet concentration is 50 ppb. Chlorine emissions are based on a maximum outlet concentration of 2.5 ppm or 2500 ppb. The CVD chambers are in operation 75 % of the time i.e. 6,570 hours annually. Please refer to Appendix I for more details of emissions from specific CVD chambers based on operating schedule and flow rates.

Table 5: Toxic emissions from process gases and chamber clean gases

Chemical	Annual throughput	Emissions after abatement		Chronic Trigger Level	HRSA?	Acute Trigger Level	HRSA?
	[lbs/yr]	[lbs/yr]	[lbs/hr]	[lbs/yr]		[lbs/hr]	
Arsine	60,000	2.28E-01	5.36E-05	5.80E-01	**No**	4.40E-04	**No**
Phosphine	15,000	6.49E-02	1.52E-05	3.10E+01	**No**	N/A	**No**
Chlorine	2,500	5.53E-01	1.30E-04	7.70E+00	**No**	4.60E-01	**No**

The printing inks and colorants contain a number of toxic materials; emissions from these are presented below in Tables 6 and 7. None of the toxics are above the trigger levels so a health risk screening analysis is not required.

Table 6: Toxic emissions from printing inks

Toxic chemicals in product	Annual Throughput	Max % of toxic chemical	Density of product	Toxic emissions (1% of total quantity)	
	[gals/yr]	%	[lbs/gal]	[lbs/yr]	[lbs/hr]
UV Plating Resist Blue (DXT - 2619)					
Formaldehyde	50	2.5	9.608	0.120	1.41E-05
Toluene	50	2.5	9.608	0.120	1.41E-05
UV Plating Resist Blue (DXT - 2620)					
Formaldehyde	50	2.5	9.676	0.121	1.42E-05
Toluene	50	2.5	9.676	0.121	1.42E-05
Resist Ink Scr Black (ETSA - 1150)					
Formaldehyde	50	12.5	9.588	0.599	7.03E-05
Phenol	50	12.5	9.588	0.599	7.03E-05
Resist Ink Scr Clear (CXT - 0698)					
Formaldehyde	50	12.5	8.894	0.556	6.52E-05
Phenol	50	12.5	8.894	0.556	6.52E-05

Table 7: HRSA trigger levels from printing ink toxic emissions

Chemical	Toxic emissions		Chronic Trigger Level	Acute Trigger Level	HRSA Triggered?
	[lbs/yr]	[lbs/hr]	[lbs/yr]	[lbs/hr]	
Phenol	1.16	1.36E-04	7700	13	**No**
Formaldehyde	1.40	1.64E-04	18	0.12	**No**
Toluene	0.241	2.83E-05	12000	82	**No**

BEST AVAILABLE CONTROL TECHNOLOGY (BACT)

In accordance with Regulation 2, Rule 2, Section 301, BACT is triggered for any new or modified source with the potential to emit 10 pounds or more per highest day of POC, NPOC, NO_x, CO, SO_2 or PM_{10}. Based on the emission calculations above (Table 3), POC emissions are under 10 lb/day, and the owner/operator is not subject to BACT.

OFFSETS

Per Regulation 2-2-302, offsets must be provided for any new or modified source at a facility that emits, or is permitted to emit, more than 10 TPY of POC or NOx. Based on the emissions displayed in Table 4, offsets are not required for this application.

NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPs)

Subpart BBBBB: NESHAPs for semiconductor manufacturing does not apply to this operation since it is not a major source of Hazardous Air Pollutants (HAPs).

STATEMENT OF COMPLIANCE

The owner/operator of S-2 is subject to the requirements of Regulation 8, Rule 30 Semiconductor Wafer Manufacturing Operations. This regulation also applies to solar cell manufacturing facilities, such as Alta Devices.

S-2 is subject to several rules related to solvent usage. S-2 is subject to the solvent sink requirement listed in 8-30-304. In addition, S-2 is subject to the fabrication area wipe cleaning requirements of 8-30-307. The aforementioned rules limit VOC emissions from solvent usage. S-2 is not subject to 8-30-302 since no photoresist developer is used.

S-2 is subject to the recordkeeping requirements of 8-30-501 and 8-30-503 (only applicable for solvent spray and vapor stations if any). Per this regulation, the quantity of all chemicals containing VOCs must be recorded on an annual basis.

This application is considered to be ministerial under the District's CEQA regulation 2-1-311 and therefore is not subject to CEQA review. The engineering review for this project requires only the application of standard permit conditions and standard emission factors and therefore is not discretionary as defined by CEQA (Permit Handbook Chapter 7.4).

This facility is not subject to PSD because it is not major as defined by Regulation 2-6-212.

Summit Public School: Denali, a middle school with over 300 students located at 495 Mercury Dr, Sunnyvale, CA 94085 is within 1000 ft of Alta Devices, Inc. Hence, this application is subject to the public notice requirement of 2-1-412. Since the increased throughput amounts of process gases, arsine, chlorine and phosphine, which are classified as toxic air contaminants, as well as formaldehyde, phenol and toluene will result in increased emissions a public notice needs to be prepared and distributed to parents and guardians of students living within a quarter-mile of the source and to each address within 1,000 ft of the school. After the notice is distributed, 30 days will be given for receiving comments from the public. These comments will be reviewed and responses will be prepared before any final decision is taken in regards to the application.

Semiconductor facilities in California may be subject to the Regulation to Reduce Greenhouse Gas Emissions from Semiconductor Operations. This regulation is aimed at reducing fluorinated gas emissions, because of their high global warming potential, from the semiconductor industry pursuant to the California Global Warming Solutions Act of 2006. Since this facility does not use any fluorinated gases, the stipulations of this regulation do not apply to them. A facility-wide permit condition prohibiting the use of these gases has been added.

PERMIT CONDITIONS

Condition No. 26244

1. The owner/operator of S-2 shall not exceed the following gross usage limits at the chemical vapor deposition chambers during any consecutive twelve-month period:

Arsine	60000 pounds

Phosphine	15000 pounds
Chlorine	2500 pounds
Trimethyl Gallium	5000 pounds
Trimethyl Indium	150 pounds
Trimethyl Aluminum	150 pounds
Carbon Tetrabromide	150 pounds
Diethyl Zinc	20 pounds
Disilane	22 pounds

(Basis: Cumulative Increase)

2. The owner/operator of S-2 shall not exceed the following gross usage limits for wipe cleaning within the source during any consecutive twelve-month period:

Acetone	500 Gallons
Isopropyl Alcohol (IPA)	300 Gallons

(Basis: Cumulative Increase)

3. The owner/operator of S-2 shall not exceed the following gross usage limits of the following chemicals during any consecutive twelve-month period:

UV Plating Resist Blue (DXT – 2619)	50 gallons
UV Plating Resist Blue (DXT – 2620)	50 gallons
Resist Ink Scr Black (ETSA – 1150)	50 gallons
Resist Ink Scr Clear (CXT - 0698)	50 gallons

(Basis: Cumulative Increase)

4. The owner/operator may use an alternate coating(s) or cleanup solvent(s) other than the materials specified in Part 2 and 3 and/or usages in excess of those specified in Part 2 and 3, provided that the owner/operator can demonstrate that all of the following are satisfied:
   a. Total POC emissions from S-2 do not exceed 2763 pounds in any consecutive twelve month period and 10 pounds per highest day;
   b. Total NPOC emissions from S-2 do not exceed 3300 pounds in any consecutive twelve month period and 10 pounds per highest day; and
   c. The use of these materials does not increase toxic emissions above any risk screening trigger level.

For the purposes of emission calculations, 100% of the gross usage for wipe cleaning shall be assumed to be emitted, and 90% of the gross usage at the printers shall be assumed to be emitted, unless the Air Pollution Control Officer has provided written approval to the owner/operator of this source to use other emission factors.
(Basis: Cumulative Increase; Toxics)

5. The owner/operator of S-2 shall abate emissions with the following general release and catastrophic release abatement devices, which must be properly maintained and properly operated, at all periods of operation of S-2:

A-6	Europa Dry Scrubber, Jupiter Scientific 2+
A-7	Europa Dry Scrubber, Jupiter Scientific 2+

A-8	Europa Dry Scrubber, Jupiter Scientific 2+
A-9	Europa Dry Scrubber, Jupiter Scientific 2+
A-10	Europa Dry Scrubber, Jupiter Scientific 2+
A-11	Europa Dry Scrubber, Jupiter Scientific 2+
A-12	Europa Dry Scrubber, Jupiter Scientific 2+
A-17	Europa Dry Scrubber, Jupiter Scientific 2+
A-13	Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+
A-14	Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+
A-15	Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+
A-16	Olympus Dry Scrubber catastrophic release of Chlorine, Jupiter Scientific 2+

(Basis: Cumulative Increase, Toxics)

6. To demonstrate compliance with part 5, the owner/operator shall ensure that all the abatement devices mentioned in part 5 are equipped with effluent sensors and a continuous effluent concentration monitor to ensure that the effluent concentration of all abatement devices is maintained as follows. The owner/operator shall calibrate the effluent sensors annually at a minimum.

   For Arsine and Phosphine:

A-4, A-5 (connected to Crius II tools):	50 ppb
A-1, A-6, A-7, A-8, A-9, A-10, A-11, A-12, A-17:	25 ppb

   For Chlorine

A-1, A-4, A-5, A-6, A-7, A-8, A-9, A-10, A-11, A-12, A-17:	2,500 ppb

   (Basis: Cumulative Increase)

7. To determine compliance with the above parts, the owner/operator shall maintain the following records and provide all of the data necessary to evaluate compliance with the above parts, including the following information:
   a. Quantities of each type of coating and solvent used at this source, and emissions calculations for this source, on a daily and monthly basis.
   b. If a material other than those specified in Part 1-3 is used, POC/NPOC and toxic component contents of each material used; and mass emission calculations to demonstrate compliance with Part 4, on a daily and monthly basis;
   c. Monthly usage and/or emission calculations shall be totaled for each consecutive twelve-month period;
   d. Daily records of the effluent concentration described in Part 6; and
   e. Dates of canister replacement for abovementioned abatement devices.

   All records shall be retained on-site for two years, from the date of entry, and made available for inspection by District staff upon request. These recordkeeping requirements shall not replace the recordkeeping requirements contained in any applicable District Regulations.

   (Basis: Cumulative Increase; Toxics)

Facility-wide Condition No. 26246

The owner/operator may not use any fluorinated gases listed in California Code of Regulations (CCR) Section 95322 (a)(9) or other fluorinated gases.
(Basis: CCR Title 17 Sections 95320-95326; 2-1-305)

RECOMMENDATION

The District has reviewed the material contained in the permit application for the proposed project and has made a determination that the project will comply with all applicable requirements of District, state, and federal air quality-related regulations. The preliminary recommendation is to issue a Permit to Operate for the equipment listed below. However, the proposed source will be located within 1,000 feet of a school, which triggers the public notification requirements of District Regulation 2-1-412. After public comments are received and reviewed, the District will make a final determination on the permit.

I recommend that the District initiate a public notice and consider any comments received prior to taking any final action on issuance of a Permit to Operate for the following sources:

S-2	**Cleanroom (Fabrication Area #1)**
A-6	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-7	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-8	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-9	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-10	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-11	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-12	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-17	**Europa Dry Scrubber, Jupiter Scientific 2+**
A-13	**Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+**
A-14	**Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+**
A-15	**Olympus Dry Scrubber catastrophic release of Arsine/Phosphine, Jupiter Scientific 2+**
A-16	**Olympus Dry Scrubber catastrophic release of Chlorine, Jupiter Scientific 2+**

Prepared by: ______________________________ Date____________________________
Simrun Dhoot
Air Quality Engineer

Appendix I

Tables 8, 9 and 10 contain details of arsine phosphine and chlorine emissions from all different CVD tools

Table 8: Arsine emissions

CVD Tool	Abatement Device	Abatement Device Number	Status	Max. uptime	Max. time for arsine	Maximum flowrate[1]	Max. outlet conc.	Arsine Emissions	
				[hours/year]	%	[sL/min]	[ppb]	[lbs/yr]	[lbs/hour]
Roth & Rau (3 chambers)	TechHarmonic	A-1	Existing	6570	50	200	25	7.14E-03	1.68E-06
T&S (R&D)	TechHarmonic	Exempt	Existing	6570	50	75	25	2.68E-03	6.28E-07
Crius II	Jupiter Europa	A-4	Existing	6570	58	250	50	2.07E-02	4.86E-06
Crius II	Jupiter Europa	A-5	Existing	6570	58	250	50	2.07E-02	4.86E-06
K475	Jupiter Europa	A-6	Proposed	6570	58	250	25	1.04E-02	2.43E-06
R6 #1	Jupiter Europa	A-7	Proposed	6570	88	400	25	2.51E-02	5.90E-06
R6 #2	Jupiter Europa	A-8	Proposed	6570	88	400	25	2.51E-02	5.90E-06
R6 #3	Jupiter Europa	A-9	Proposed	6570	88	400	25	2.51E-02	5.90E-06
R6 #4	Jupiter Europa	A-10	Proposed	6570	88	400	25	2.51E-02	5.90E-06
R6 #5	Jupiter Europa	A-11	Proposed	6570	88	400	25	2.51E-02	5.90E-06
R6 #6	Jupiter Europa	A-12	Proposed	6570	88	400	25	2.51E-02	5.90E-06
Hercules	Jupiter Europa	A-17	Proposed	6570	50	450	25	1.61E-02	3.77E-06
								2.28E-01	**5.36E-05**

[1] Flowrate of carrier gas and arsine

Table 9: Phosphine Emissions

CVD Chamber	Abatement Device	Abatement Device Number	Status	Maximum annual uptime	Maximum % of time arsine may flow	Maximum flowrate[2]	Maximum outlet concentration	Phosphine Emissions	
				[hours/year]	%	[sL/min]	[ppb]	[lbs/yr]	[lbs/hour]
Roth & Rau (3 chambers)	TechHarmonic	A-1	Existing	6570	1	200	25	1.43E-04	3.35E-08
T&S (R&D)	TechHarmonic	Exempt	Existing	6570	50	75	25	2.68E-03	6.28E-07
Crius II	Jupiter Europa	A-4	Existing	6570	50	250	50	1.78E-02	4.19E-06
Crius II	Jupiter Europa	A-5	Existing	6570	50	250	50	1.78E-02	4.19E-06
K475	Jupiter Europa	A-6	Proposed	6570	50	250	25	8.92E-03	2.09E-06
R6 #1	Jupiter Europa	A-7	Proposed	6570	10	400	25	2.86E-03	6.70E-07
R6 #2	Jupiter Europa	A-8	Proposed	6570	10	400	25	2.86E-03	6.70E-07
R6 #3	Jupiter Europa	A-9	Proposed	6570	10	400	25	2.86E-03	6.70E-07
R6 #4	Jupiter Europa	A-10	Proposed	6570	10	400	25	2.86E-03	6.70E-07
R6 #5	Jupiter Europa	A-11	Proposed	6570	10	400	25	2.86E-03	6.70E-07
R6 #6	Jupiter Europa	A-12	Proposed	6570	10	400	25	2.86E-03	6.70E-07
Hercules	Jupiter Europa	A-17	Proposed	6570	1	450	25	3.21E-04	7.54E-08
								6.49E-02	**1.52E-05**

[2] Flowrate of carrier gas and phosphine

Table 10: Chlorine Emissions

CVD Chamber	Abatement Device	Abatement Device Number	Status	Maximum annual uptime	Maximum % of time chlorine may flow	Maximum flowrate[3]	Maximum outlet concentration	Chlorine Emissions	
				[hours/year]	%	[sL/min]	[ppb]	[lbs/yr]	[lbs/hour]
Roth & Rau (3 chambers)	TechHarmonic	A-1	Existing	6570	2	200	2500	2.86E-02	6.70E-06
T&S (R&D)	TechHarmonic	Exempt	Existing	6570	2	75	2500	1.07E-02	2.51E-06
Crius II	Jupiter Europa	A-4	Existing	6570	2	250	2500	3.57E-02	8.38E-06
Crius II	Jupiter Europa	A-5	Existing	6570	2	250	2500	3.57E-02	8.38E-06
K475	Jupiter Europa	A-6	Proposed	6570	2	250	2500	3.57E-02	8.38E-06
R6 #1	Jupiter Europa	A-7	Proposed	6570	2	400	2500	5.71E-02	1.34E-05
R6 #2	Jupiter Europa	A-8	Proposed	6570	2	400	2500	5.71E-02	1.34E-05
R6 #3	Jupiter Europa	A-9	Proposed	6570	2	400	2500	5.71E-02	1.34E-05
R6 #4	Jupiter Europa	A-10	Proposed	6570	2	400	2500	5.71E-02	1.34E-05
R6 #5	Jupiter Europa	A-11	Proposed	6570	2	400	2500	5.71E-02	1.34E-05
R6 #6	Jupiter Europa	A-12	Proposed	6570	2	400	2500	5.71E-02	1.34E-05
Hercules	Jupiter Europa	A-17	Proposed	6570	2	450	2500	6.42E-02	1.51E-05
								5.53E-01	**1.30E-04**

[3] Flowrate of carrier gas and chlorine