Silicon Dioxide Characterization
From Intel, NM Recuperative Thermal Oxidizers

28-Apr-2004

Results of silicon dioxide sampling and analysis from RTO operations during Feb. and Mar. 2004.

Background & Purpose

Intel's recuperative thermal oxidizers (RTOs) burn various process solvents, including one known as hexamethyldisilazane (HMDS). The combustion of HMDS forms the solid by-product silicon dioxide (SiO_2). SiO_2 exists in two forms: a non-crystalline (a.k.a. amorphous) form such as glass and a crystalline form such as quartz, a major component of sand and a lesser component of soils. Crystalline SiO_2 represents a significantly greater health risk, due to its much greater association with lung diseases from elevated and extended inhalation exposures.

A concern has been expressed by the community about the type and quantity of SiO_2 emissions from Intel's RTOs. Intel had the solid material evaluated many years ago. In early 2004, Intel repeated the effort by analyzing samples collected from the exhaust stream and from inside the thermal oxidizer.

Methods

EPA methods RM5/17 were used to collect emission particles onto pre-weighed filters in the Fab 11W, Fab 11S, Fab 11XB, and the Fab 11XF RTOs in February and March 2004. The sampling duration was six to eight hours to ensure that sufficient quantities of particulate matter (PM) were collected for analysis. The samples were submitted to an accredited, third-party laboratory for analysis. The quantity of PM collected onto the filters was determined by drying and then weighing the filters. An average concentration of PM, in pounds per hour, was calculated, based on the volume of air sampled and the airflow through the RTO. The filters, after weighing, then were analyzed for crystalline SiO_2 content by an x-ray diffraction method, using a validated National Institute of Occupational Safety and Health (NIOSH) analytical method (NMAM #7501).

A sample of solid material was obtained from the oxidizer enclosure of the Fab 11S RTO during a scheduled maintenance procedure in March 2004. This sample was submitted for analysis of crystalline SiO_2 content (NIOSH method NMAM #7500), using a different accredited laboratory. The sample also was analyzed for elemental content at an Intel laboratory, using an energy-dispersive x-ray (EDX) analytical method.

Results & Conclusions

Table 1 summarizes the composition results. No crystalline SiO_2 was detected either in the RTO emissions samples or in the solid material collected from the interior of an RTO oxidizer. Also, silicon and oxygen were the only elements identified by the EDX analysis of the oxidizer sample. These results show that the crystalline form of SiO_2 is not associated with RTO operations.

Table 1. Crystalline SiO_2 and elemental content of RTO emissions and oxidizer samples.

Sample source	Crystalline SiO_2 content (NMAM #7500 or #7501)	Elemental composition (EDX) ^
Fab 11W RTO emissions stack	≤ 1 % *	n/a
Fab 11S RTO emissions stack	≤ 1 % *	n/a
Fab 11X B RTO emissions stack	≤ 1 % *	n/a
Fab 11XF RTO emissions stack	≤ 1 % *	n/a
Fab 11S RTO oxidizer enclosure	≤ 1 % *	silicon (Si) and oxygen (O)

* The listed value represents the lower limit of detection by the analytical method (i.e., less than or equal to one percent).

^ The EDX methods identifies elements with atomic number of 6 (carbon) or greater.

The emission rates and emission limits for particulate matter (PM) are listed in Table 2. These results show that the RTO PM emissions are well-below permitted limits.

Table 2. Measured and permitted PM rates for RTOs.

RTO	Measured particulate emissions rate (lb. / hr.)	Permitted particulate emissions rate (lb. / hr.)
Fab 11W	0.06	4.5
Fab 11S	0.18	4.5
Fab 11XB	0.04	4.5
Fab 11XF	0.04	4.5

Efforts To Reduce Thermal Oxidizer Downtime

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Progress Update

- Why:
  - Per the CEWG request, Intel worked to scheduled its preventative maintenance on the thermal oxidizers to minimize downtime by doing maintenance on the system around the clock (24 hrs / day).
- Results:
  - The total downtime for preventative maintenance was reduced over 70% from 2004 to 2005
  - The average downtime for preventative maintenance was reduced from about 49 hours to 17 hours

Continuous Improvements:

- In 2006, Intel will make every effort to schedule preventative maintenance when the weather is right for good dispersion, ie "burn days"

Backup

Report Tracking Number	Equipment Involved	Date System Down	Date System Restarted	Total time in bypass (hrs)	Estimated VOC emissions (lbs)
EHS-04-1.004	F11S RTO	3/9/2004	3/11/2004	57.2	413.2
EHS-04-1.013	F11W RTO	4/27/2004	4/29/2004	62.2	620.3
EHS-04-1.018	Fab 7 RTO	5/11/2004	5/12/2004	38.8	15.6
EHS-04-1.028	F11X Bridge RTO	9/6/2004	9/7/2004	39.75	66.0
EHS-04-1.029	F11X FAB RTO	9/20/2004	9/21/2004	39.1	278
EHS-04-1.030	F11S RTO	10/18/2004	10/20/2004	43.3	312.8
EHS-04-1.033	F11W RTO	11/2/2004	11/4/2004	62.2	635.7
			2004 Average:	**48.9**	**N/A**
			2004 Total:	**342.6**	**2,341.6**

Report Tracking Number	Equipment Involved	Date System Down	Date System Restarted	Total time in bypass (hrs)	Estimated VOC emissions (lbs)
EHS-05-1.005	Fab 11W RTO	4/28/2005	4/28/2005	17.2	175.8
EHS-05-1.007	Fab 11S RTO	5/4/2005	5/4/2005	14.7	106.2
EHS-05-1.020	Fab 11X Bridge RTO	9/7/2005	9/7/2005	15.6	25.9
EHS-05-1.022	Fab 11X Fab RTO	9/20/2005	9/21/2005	23.2	165.7
EHS-05-1.024	Fab 11S RTO	10/19/2005	10/19/2005	15.4	111.0
EHS-05-1.026	Fab 11W RTO	11/1/2005	11/4/2005	14.5	146.7
			2005 Average:	**16.8**	**N/A**
			2005 Total:	**100.6**	**584.6**

Note: The EHS-05-1.026 report emissions and time in bypass were scaled to reflect 14.5 hours for preventative maintenance. Total downtime reported was 84 hours and included other project work.