

EXHIBIT F

Smoke Gas Toxicity

Petition No. 1609

RS/DS

Extensive research and testing was conducted and reported by TÜV Rheinland Energie und Umwelt GmbH, et al. in *Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization*, June 2018.

A standard crystalline glass thick-film module was subjected to a 150 kW burner output for 20 minutes. During the test, smoke gas was collected and analyzed. By the end of the test, “the modules were destroyed over wide areas.”

The study included calculated values of the total release of arsenic, lead, cadmium, selenium, carbon dioxide, carbon monoxide, and formaldehyde in the smoke produced by the test.

Comparing the size of the test panel with the size of the panels proposed for this project and multiplying by the proposed quantity of panels on this site, we can see that the total physical volume of modules is 3,180 times greater.

Test panel size: $1655\text{mm} * 1000\text{mm} * 45\text{mm} = 74,475,000\text{mm}^3$

Proposed panel size: $2384\text{mm} * 1096\text{mm} * 35\text{mm} = 91,450,240\text{mm}^3$

Proposed quantity of panels: 2590

$$\frac{\text{Size of proposed facility}}{\text{Size of test panel}} = \frac{91,450,240\text{mm}^3 * 2,590}{74,475,000\text{mm}^3} = 3,180$$

We can therefore multiply the total release values provided in the study by 3180 to estimate the mass of the chemicals produced by a fire affecting a solar facility of this size. These values are provided in the table below. The comparative data in the three columns on the right are from DHHS (NIOSH) Publication No. 2005-149, “NIOSH POCKET GUIDE TO CHEMICAL HAZARDS”

	Total Release, test panel [1]	Calculated total release, solar facility	Immediately Dangerous to Life or Health Concentrations (IDLH)	NIOSH Recommended Exposure Limit (REL)	Potential Carcinogen per NIOSH?
Arsenic	1 mg	3,180 mg	5 mg/ m ³	Ceiling: 0.002 mg/m ³ [15 minute]	YES
Lead	760 mg	2,416,800 mg	100 mg/m ³	TWA: 0.100 mg/m ³	Not Listed
Cadmium	72 mg	228,960 mg	9 mg/m ³	0	YES
Selenium	12 mg	38,160 mg	1 mg/m ³	TWA: 0.2 mg/m ³	Not Listed
Carbon dioxide	4,543 g	14,446,740 g	40,000 ppm (72,000 mg/m ³)	TWA: 9,000 mg/m ³ ST: 54,000 mg/m ³	Not Listed
Carbon monoxide	36 g	114,480 g	1,200 ppm (1,374 mg/m ³)	TWA 40 mg/m ³ Ceiling: 229 mg/m ³ [15-minute]	Not Listed
Formaldehyde	1.1 g	3,498 g	Ca [20 ppm] (26.56 mg/m ³)	TWA 0.016 ppm Ceiling 0.1 ppm [15-minute]	YES

[1] Page 295 of *Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization*

The same 3,180 multiplier could be applied to the Test 1B values in the table below to roughly estimate total heat release and smoke production.

Heat release, smoke development and damage to the specimen

		Test 1A	Test 1B	Test 1C
Test duration	(s)	1,200	1,200	600
Maximum heat release rate	(kW)	29.2	246.6	272.9
Average heat release rate	(kW)	6.4	49.3	46.2
Total heat release	(kJ)	7,631	59,197	27,747
Maximum smoke production rate*	(m ² /s)	0.12	0.78	2.05
Average smoke production rate*	(m ² /s)	0.03	0.15	0.12
Total smoke production*	(m ²)	41	182	73
Initial mass of specimen	(g)	19,978	20,022	19,882
Residual mass of specimen	(g)	19,525	5,502	10,375
Mass loss	(g)	453	14,520	9,507
Mass loss	(%)	2.3	72.5	47.8
Mass of fire residue	(g)	143	12,798	n.i.
Burned mass	(g)	310	1,722	n.i.
Destroyed area	(m ²)	0.54	1.53	0.97

* The smoke production is given in m², i.e. the area projected by the sum of all smoke particles onto a 2-dimensional plane