Evaluation of General Electric LM-6000 Simple-Cycle Gas Turbine Particulate (Emissions Data)

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A sample data set of 42 measurements of current emissions ranges from 0.6746 lb/hr to 2.44 lb/hr, as seen in Table 1. An assumption in the memorandum is that these values represent random, independent data (that is, the data is not biased). Suggested thresholds such as 1.97 lb/hr have already been exceeded, so it is clearly not appropriate to infer that members the overall population would not include exceeding values. General Electric offers guarantees that are based on an 85% confidence interval with 97.5% pass rate. Although we do not have General Electric's specific protocol for calculating such a level, such a guarantee suggests the application of a tolerance interval that includes a specified portion of the observations from a population or process (with a prescribed degree of confidence).

TABLE 1
Summary of PM10 Emission Source Test Data

Facility	Test Date	Source	PM10 lb/hour
Creed Energy Center	1/31/2003	S-1	2.18
Creed Energy Center	7/6/2006	S-1	1.363
Creed Energy Center	5/7/2009	S-1	0.6746
Lambie Energy Center	1/16/2003	S-1	1.9
Lambie Energy Center	5/5/2006	S-1	2.104
Lambie Energy Center	5/11/2009	S-1	0.83
Los Esteros Energy	7/26-7/27/05	S-1	2.266
Los Esteros Energy	7/26-7/27/05	S-2	0.896
Los Esteros Energy	7/28/2005	S-3	1.44
Los Esteros Energy	7/27-7/29/05	S-4	0.915
Los Esteros Energy	9/8/2006	S-1	0.775
Los Esteros Energy	9/8/2006	S-2	0.871
Los Esteros Energy	9/6-9/7/06	S-3	1.805
Los Esteros Energy	9/6-9/7/06	S-4	0.904
Los Esteros Energy	7/25-7/26/07	S-1	1.672
Los Esteros Energy	7/25-7/26/07	S-2	1.429
Los Esteros Energy	7/24-7/25/07	S-3	1.456
Los Esteros Energy	7/24-7/25/07	S-4	1.646

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Creed Energy Center	1/31/2003	S-1	2.18
Creed Energy Center	7/6/2006	S-1	1.363
Creed Energy Center	5/7/2009	S-1	0.6746
Los Esteros Energy	5/29-5/30/08	S-1	1.4145
Los Esteros Energy	5/28-5/29/08	S-2	0.9769
Los Esteros Energy	5/28-5/29/08	S-3	1.49
Los Esteros Energy	5/29-5/30/08	S-4	2.21
Los Esteros Energy	5/13/2009	S-1	1.16
Los Esteros Energy	5/14-5/15/09	S-2	0.969
Los Esteros Energy	5/14-5/15/09	S-3	0.864
Los Esteros Energy	5/13-5/14/09	S-4	1.04
Riverview	5/8/2009	S-1	1.469
Wolfskill	6/2/2004	S-1	2.15
Wolfskill	7/5/2006	S-1	1.9
Wolfskill	5/4/2009	S-1	0.81
Gilroy Energy Center	7/19/2005	S-3	1.9
Gilroy Energy Center	7/21/2005	S-4	1.7
Gilroy Energy Center	7/21/2005	S-5	1
Gilroy Energy Center	5/23/2006	S-3	1.69
Gilroy Energy Center	5/24/2006	S-4	0.95
Gilroy Energy Center	5/22/2006	S-5	1.41
Gilroy Energy Center	5/23/2007	S-3	1.6
Gilroy Energy Center	5/24/2007	S-4	1.25
Gilroy Energy Center	5/25/2007	S-5	1.6
Goosehaven	1/23/2003	S-1	2.44
Goosehaven	7/6/2006	S-1	2.438
Goosehaven	5/6/2009	S-1	0.9716

Reference: Table 11 of the Marsh Landing Generating Station Project, Preliminary Determination of Compliance, March 2010.

A discussion of the calculation of tolerance intervals has recently been reviewed by the United States EPA (USEPA, 2009). Calculating an 85% upper confidence limit on the 97.5th percentile (also know as an 85/97.5 upper tolerance limit or UTL) with the 42 available emission values yields a gamma UTL of 3.07 lb/hr. The data appears to adhere more closely to a gamma distribution than other common distributions such as normal or lognormal.

Considering the exact level of the calculated UTL is not as important as noting that it exceeds suggested thresholds such as 1.97 lb/hr. An alternative way to view this is to note that of the 42 observed emission rate values, 7 exceeded 1.97 lb/hr. Thus 16.7% exceeded.

Applying the binomial distribution to this (a distribution that considers two possible outcomes, such as exceeded or not exceeded, for a given number of independent trials), one can predict with 85% confidence that the percent of exceedances would fall between 10.6% and 24.7%.

One could likewise consider a suggested threshold of 2.2 lb/hr. In the sample data set of 42, there are 4 exceedances of that threshold, or 9.5%. One can predict with 85% confidence that the percent of exceedances would fall between 4.9% and 16.6%. With the thresholds of 1.97 lb/hr or 2.2 lb/hr, the interval of the percent of exceedances calculated (using the binomial distribution with 85% confidence) would not be less than 10.6% or 4.69%, respectively. Conversely it is probably not higher than 24.7% or 16.6%, respectively.

References

United States Environmental Protection Agency (USEPA), *ProUCL Version 4.00.04 Technical Guide (Draft),* Office of Research and Development, 2009.