

Example of the proposed Department's approach for determining performance of a technology through a statistical analysis of the testing data

Note, the data was randomly generated for this example and was not tested to verify normal distribution

Company X is seeking classification as an Advanced Treatment Alternate On-lot Technology in Pennsylvania; the Advanced Treatment performance standard is 10 mg/L CBOD₅ and TSS. They have submitted an application to the Department and the Department has deemed the application administratively complete. They have included their NSF40 certification report and 12 field test sites. The Department starts the technical review and it goes as follows:

Test Center data performance test

1. The NSF40 testing report is reviewed to determine if the testing occurred in a similar or colder climate than that of Pennsylvania. **YES**
 - a. Company X's NSF40 testing was completed in Massachusetts.
2. The NSF40 testing report is reviewed to determine if the testing included the winter months. **YES**
 - a. Company X's NSF40 testing occurred between August of 2001 and February of 2002.
3. The Department compiles all the test center data and performs a statistical analysis to determine the performance of the technology.
 - a. The data for both CBOD₅ and TSS are analyzed to determine if normally distributed.
 - i. Both data sets are normally distributed.
4. The Department performs a statistical analysis on the test center data to determine if the technology meets the minimum performance standards at least 85% of the time. (See NSF40 Test Center Data sheet)
 - a. The mean (\bar{x}) is calculated.
 - i. CBOD₅ is **4.27 mg/L**
 - ii. TSS is **3.85 mg/L**
 - b. The standard deviation (s) is calculated.
 - i. CBOD₅ is **3.85 mg/L**
 - ii. TSS is **4.72 mg/L**
 - c. $\bar{x} + s =$
 - i. CBOD₅ = **8.38 mg/L**
 - ii. TSS = **8.58 mg/L**
5. The technology has past the first performance test; both CBOD₅ and TSS ($\bar{x} + s$) are less than or equal to the 10 mg/L performance standard.

Field Test data performance test

1. Next the Department compiles the field testing data to verify performance at the field level.
(See Field Test Data sheet)
2. The data is statistically analyzed and is determined to be normally distributed.
 - a. The \bar{x} is calculated.
 - i. CBOD₅ is **9.00 mg/L**
 - ii. TSS is **9.04 mg/L**
 - b. The s is calculated.
 - i. CBOD₅ is **5.94 mg/L**
 - ii. TSS is **5.69 mg/L**
 - c. The size of the samples (n) is determined to be **60**.
 - d. A t value of **1.296** is pulled from a t distribution table for a one tailed 90% confidence interval.
 - e. The t value is calculated.

$$t = (10 \text{ mg/L CBOD}_5 - \bar{x}) * \left(\frac{\sqrt{n}}{s}\right)$$

$$t = (10 \text{ mg/L CBOD}_5 - 9.00 \text{ mg/L}) * \left(\frac{\sqrt{60}}{5.94 \text{ mg/L}}\right)$$

$$\mathbf{t_{CBOD_5} = 1.309}$$

$$t = (10 \text{ mg/L TSS} - \bar{x}) * \left(\frac{\sqrt{n}}{s}\right)$$

$$t = (10 \text{ mg/L TSS} - 9.04) * \left(\frac{\sqrt{60}}{5.69 \text{ mg/L}}\right)$$

$$\mathbf{t_{TSS} = 1.310}$$

3. t values for both CBOD₅ and TSS are greater than the 90% confidence interval. The technology has past the final performance test.

Note: The confidence limits for population are represented by $\bar{x} \pm t_c (s/\sqrt{n})$ Where $\pm t_c$ values are called critical values or confidence coefficients.

NSF40 Test Center Data

Date	CBOD5	TSS	Date	CBOD5	TSS	Date	CBOD5	TSS
22-Aug-01	8	3	23-Oct-01	1	3	10-Jan-02	8	4
22-Aug-01	10	6	23-Oct-01	6	1	10-Jan-02	5	3
22-Aug-01	12	2	23-Oct-01	6	10	10-Jan-02	3	3
22-Aug-01	25	2	23-Oct-01	4	1	10-Jan-02	3	2
28-Aug-01	13	3	23-Oct-01	6	3	22-Jan-02	4	2
28-Aug-01	8	3	30-Oct-01	1	3	26-Jan-02	5	6
28-Aug-01	5	4	30-Oct-01	1	2	26-Jan-02	2	2
28-Aug-01	7	2	30-Oct-01	1	1	28-Jan-02	1	2
28-Aug-01	6	2	7-Nov-01	3	5	28-Jan-02	1	3
4-Sep-01	13	4	7-Nov-01	4	2	28-Jan-02	1	3
4-Sep-01	17	4	7-Nov-01	4	2	28-Jan-02	6	3
4-Sep-01	11	4	7-Nov-01	8	1	28-Jan-02	3	3
4-Sep-01	4	1	13-Nov-01	1	3	28-Jan-02	2	2
4-Sep-01	1	11	13-Nov-01	1	1	5-Feb-02	8	3
10-Sep-01	1	3	13-Nov-01	7	1	5-Feb-02	4	5
10-Sep-01	3	1	13-Nov-01	5	1	5-Feb-02	3	4
10-Sep-01	13	1	13-Nov-01	3	2	5-Feb-02	2	1
10-Sep-01	13	1	21-Nov-01	6	4	5-Feb-02	3	2
10-Sep-01	1	1	21-Nov-01	9	2	13-Feb-02	3	10
16-Sep-01	1	2	21-Nov-01	10	4	13-Feb-02	2	1
16-Sep-01	1	2	21-Nov-01	9	4	13-Feb-02	1	2
16-Sep-01	1	3	27-Nov-01	4	6	13-Feb-02	2	4
16-Sep-01	9	1	27-Nov-01	3	2			
16-Sep-01	3	2	27-Nov-01	1	4	CBOD5		
24-Sep-01	1	4	27-Nov-01	1	19	Mean		TSS Mean
24-Sep-01	1	3	27-Nov-01	1	3	4.27		3.85
24-Sep-01	4	4	4-Dec-01	1	3	CBOD5		TSS
24-Sep-01	4	4	4-Dec-01	1	3	StdDev		StdDev
24-Sep-01	5	3	4-Dec-01	2	2	4.11		4.72
3-Oct-01	2	1	4-Dec-01	1	4	CBOD5		TSS Mean
3-Oct-01	1	3	10-Dec-01	1	7	Mean Plus		Plus One
3-Oct-01	1	3	17-Dec-01	5	14	One StdDev		StdDev
3-Oct-01	1	4	17-Dec-01	3	10	8.38		8.58
9-Oct-01	6	5	17-Dec-01	2	5			
9-Oct-01	5	16	17-Dec-01	1	3			
9-Oct-01	4	2	17-Dec-01	1	1			
9-Oct-01	1	3	17-Dec-01	2	5			
9-Oct-01	1	3	29-Dec-01	3	5			
16-Oct-01	15	42	30-Dec-01	3	3			
16-Oct-01	4	6	30-Dec-01	2	2			
16-Oct-01	2	2	30-Dec-01	3	3			
16-Oct-01	1	3	30-Dec-01	3	3			
16-Oct-01	1	1	30-Dec-01	3	3			

Field Test Data

Location	Date	CBOD5 mg/L	TSS mg/L	Location	Date	CBOD5 mg/L	TSS mg/L
Site 1	21-Jan-14	8.0	2.8	Site 8	3-Jan-11	9.4	1.6
Site 1	21-Apr-14	15.7	16.1	Site 8	29-Mar-11	10.6	8.3
Site 1	24-Jul-14	20.0	19.7	Site 8	28-Jul-11	11.9	13.9
Site 1	15-Oct-14	12.6	7.3	Site 8	8-Nov-11	1.0	19.4
Site 2	5-Feb-13	11.7	3.3	Site 9	15-Jul-16	7.2	3.6
Site 2	15-May-13	9.7	11.6	Site 9	22-Nov-16	17.0	8.5
Site 2	9-Aug-13	6.3	17.7	Site 9	14-Jan-17	6.3	20.3
Site 2	23-Nov-13	17.2	17.6	Site 9	3-Apr-17	15.1	8.8
Site 3	29-Jan-15	9.5	4.8	Site 10	16-Sep-14	6.1	13.0
Site 3	3-May-15	17.1	7.5	Site 10	20-Dec-14	1.6	2.9
Site 3	10-Aug-15	2.6	10.9	Site 10	27-Feb-15	19.3	12.8
Site 3	7-Nov-15	10.8	12.6	Site 10	23-Jun-15	14.1	12.9
Site 3	15-Feb-16	3.2	4.7	Site 10	30-Sep-15	19.9	16.1
Site 3	10-May-16	6.2	4.6	Site 11	29-May-10	17.4	18.1
Site 4	15-Dec-12	1.1	2.6	Site 11	24-Aug-10	17.9	4.1
Site 4	22-Mar-13	15.1	3.7	Site 11	9-Nov-10	20.1	1.4
Site 4	21-Jun-13	20.8	1.8	Site 11	3-Feb-11	1.3	6.9
Site 4	15-Sep-13	2.2	9.8	Site 12	4-May-11	11.4	6.2
Site 4	10-Dec-13	13.7	10.2	Site 12	29-Jul-11	6.2	19.1
Site 5	13-Jan-10	11.7	12.6	Site 12	31-Oct-11	8.0	17.0
Site 5	29-Mar-10	11.1	17.3				
Site 5	6-Jun-10	5.5	14.2	# of Samples (n)		60	
Site 5	17-Aug-10	5.5	18.0	t value for 90% confidence interval			1.296
Site 5	15-Oct-10	18.5	12.2	CBOD5		TSS	
Site 5	8-Jan-11	10.9	2.8	Mean	9.00	Mean	9.04
Site 5	29-Apr-11	10.8	20.5	StdDev	5.94	StdDev	5.69
Site 5	11-Jun-11	17.7	17.3	t value	1.309	t value	1.310
Site 5	25-Sep-11	3.2	3.2				
Site 6	10-Jan-08	20.3	13.0				
Site 6	13-Mar-08	4.6	15.5				
Site 6	17-Jun-08	4.7	5.0				
Site 6	27-Sep-08	13.6	9.4				
Site 6	10-Dec-08	11.8	8.3				
Site 6	24-Jan-10	18.2	9.1				
Site 6	11-Mar-10	9.8	3.8				
Site 7	2-Feb-09	7.5	9.5				
Site 7	22-Apr-09	2.5	16.8				
Site 7	11-Jul-09	15.3	6.2				
Site 7	10-Oct-09	3.3	16.7				