Determination of service standard time for liquid waste parameter in certification institution

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Abstract. Baristand Industry Medan is a technical implementation unit under the Industrial and Research and Development Agency, the Ministry of Industry. One of the services often used in Baristand Industry Medan is liquid waste testing service. The company set the standard of service 9 working days for testing services. At 2015, 89.66% on testing services liquid waste does not meet the specified standard of services company. The purpose of this research is to specify the standard time of each parameter in testing services liquid waste. The method used is the stopwatch time study. There are 45 test parameters in liquid waste laboratory. The measurement of the time done 4 samples per test parameters using the stopwatch. From the measurement results obtained standard time that the standard Minimum Service test of liquid waste is 13 working days if there is testing E. coli.

1. Introduction
Baristand Industry Medan is a technical implementation unit under the Industrial and Research and Development Agency, the Ministry of Industry. One of the services often used in Baristand Industry Medan is liquid waste testing service.

The testing is the determination of one or more of the characteristics of an object the assessment according to the procedure. The procedure itself is a way to implement an activity or process. The testing is usually applied to the ingredients, products or process according to the procedure. Meanwhile, laboratory is the place of scientific research, experiments or measurements scientific training done. Service activities and laboratory testing in general is to meet the standardization, where all types of ingredients, products and the process is in accordance with certain standards that are assigned to maintain the quality a product/service in the community/consumers. Liquid Waste is a joint or a mixture of water and pollutants carried by the good in the situation dissolved and dispersed suspended domestic (offices, housing and trade), the source of industry and on a specific time mixed with the ground water surface water or rain water.

Baristand Industry Medan specify the standard services for at least 9 working days for testing services. Working days in Baristand Medan is Monday to Friday. 2015, 89.66% on testing services liquid waste does not meet the specified standard of company. The cause of not achieving the minimum standard of services is the old testing time. Testing time is determined by how many test parameters that will be tested in accordance with the customer request. There are 45 effluent testing parameters that can be tested in Baristand Medan Industry that consists of 8 test parameters the nature of physics, 22 test parameters chemical nature, 12 test parameters of metal and 3 parameters a microbiology test. To know how long time testing each parameter, will be done measurement standard
time. The measurement of the time is done 4 samples per test parameters, because the capacity of the laboratory only can test 4 sample daily.

2. Research Method

a. The measurement of the time.
   The measurement of the working time (Time Study) was an attempt to determine the length of time the work that is required by an operator to complete a work. The measurement of the time consists of 2 types, namely the measurement of the time directly and the measurement of time indirectly [1]. The measurement of the time that is done in this research is the measurement of the time directly using the stopwatch.

b. Testing the uniformity of the data
   A data said uniform if all of the data between the two border controls, namely the limit of control over and the under-control limit. The formulation of the limit of control over and under control limit is as follows [1].
   \[
   \text{When } N' \leq N, \text{ then the amount of data is enough}
   \]
   \[
   \text{When } N' > N, \text{ then the amount of data is not enough}
   \]

c. Testing the adequacy of the data
   The adequacy of the data is done to get whether the amount of data observation result enough to do research. To count the number of measurement is required for the level of carefulness 5 percent and the level of confidence 95% is as follows [5]:
   \[
   \text{When } N' \leq N, \text{ then the amount of data is enough}
   \]
   \[
   \text{When } N' > N, \text{ then the amount of data is not enough}
   \]

d. Rating Factor and Allowance
   Rating factor is a technique to equate the result of observation of the operator in completing a work with the time required by the normal operator in completing the job. According to [2] rating factor (P) has three limitations, namely:
   \[
   p > 1 \text{ when the operator work too fast}
   \]
   \[
   p < 1 \text{ when the operator working under normal (too slowly)}
   \]
   \[
   p = 1 \text{ when the operator to work normal}
   \]
   There are many methods used to determine rating factors. The following is some method in determining the rating factor that generally used [1]:
   1. The Method Skill and Effort Rating
   2. The Method Westinghouse
   3. The Method Synthetic Rating
   4. Performance Rating or Speed Rating
   5. The Method Objective
   The giving of the allowance is intended to provide the opportunity for the operator to do the things that must be done so that the raw material is obtained can be said the complete working time data and represent the working system that is observed. The concession is given among others:
   1. Allowance for personal needs
   2. Allowance to eliminate fatigue (fatigue)
   3. Allowance to the things that could not be avoided

e. The cycle times.
   The cycle times is the time required to create one product unit on a single workstation [3]. The time required to implement the elements of the typical work element will differ slightly from the cycle to other cycle, even if the operator is working at normal speed or uniform, each of the elements in a different cycle does not always will be completed in the same time.

f. The Normal time.
   The normal time for a working operating element is shows that a good qualified operator will work completed the work on the tempo work normal [1].

g. The Standard Time.
The determination of the time standard for each parameter test is done with the way the measurement directly using the stopwatch. Standard Time is obtained by multiplying the normal time with allowance[4].

3. The results
Testing the liquid waste consists of 5 operators. Each operator to test different parameters, division test parameters based on the operator is divided into:

1. The Operator A can test for smell parameters, BOD, conductivity, turbidity, dissolved oxygen (O2), slurries dissolved, pH, taste, temperature, Total Solid Suspension (TSS), colors and organic substances.
2. The Operator B can test for fluoride parameters (F), oil/fat, NH3-N, nitrate, nitric, nitrogen total, phosphate, cyanide and sulfide.
3. The Operator C can test alkalinity parameters, COD, calcium, hardness, chloride, magnesium, salinity, silica, mercury, arsenic, iron, cadmium, chrome, cobalt, potassium, manganese, nickel, zinc, copper, and lead.
4. The Operator D can test for total coliform parameters, E. coli, and numbers total fins.
5. The Operator E can test for boron parameters.

Testing cycle time consisted of several activities namely:

1. Preparing the equipment and the chemicals for the testing process.
2. Testing process. On this testing process for each different test parameters. The activities on this testing process consists of weigh the chemical, make the solution, add some ml solution, do titration, do distillation, heat sample, create calibration curve and read the examples on spectrophotometer test.
3. Perform the calculation of the test results and record the test results.
   For example, activities test parameters smell.

| Activities                          | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|-------------------------------------|----|----|----|----|----|----|----|----|----|----|
| Took the beaker glass.              | 0.30 | 0.30 | 0.40 | 0.35 | 0.30 | 0.40 | 0.30 | 0.30 | 0.30 | 0.30 |
| Pour test example into the beaker   | 2.50 | 2.40 | 2.38 | 2.20 | 2.25 | 2.57 | 2.60 | 2.50 | 2.10 | 2.50 |
| glass.                              |    |    |    |    |    |    |    |    |    |    |
| Scent.                              | 0.50 | 0.55 | 0.60 | 0.45 | 0.63 | 0.50 | 0.50 | 0.40 | 0.43 | 0.50 |
| Record results.                     | 0.57 | 0.50 | 0.60 | 0.50 | 0.57 | 0.57 | 0.57 | 0.60 | 0.42 | 0.51 |
| Total Time (minutes)                | 3.87 | 3.75 | 3.98 | 3.50 | 3.75 | 4.04 | 3.97 | 3.90 | 3.25 | 3.81 |

Test the uniformity of data for smell parameter and the average time measurements smell is:

\[
\bar{x} = \frac{\sum x_i}{N}
\]  

\[
\bar{x} = \frac{3.87 + 3.75 + 3.98 + 3.50 + 3.75 + 4.04 + 3.97 + 3.90 + 3.25 + 3.81}{10} = 3.782
\]  

The Standard deviation of time measurement smell parameter is:
\[ \sigma = \sqrt{\frac{\sum(x_i-\bar{x})^2}{N-1}} \]  
(3)

\[ \sigma = \sqrt{\frac{0.527}{10}} = 0.242 \]  
(4)

The calculation of the value of control over (BKA), the limit under control (BKB) is:

\[ \text{BKA} = \bar{x} + 2\sigma = 3.782 + 2(0.242) = 4.266 \]  
(5)

\[ \text{BKB} = \bar{x} - 2\sigma = 3.782 - 2(0.242) = 3.298 \]  
(6)

Map control test uniformity odor data can be seen in Figure 1.

![Control Map Test Data Uniformity Smell](image)

**Figure 1.** Control Map Test Data Uniformity Smell

Test the adequacy data is done to see whether the data taken from the observation was sufficient for use. In this research, the level of confidence that is used is 95% then k is 2, and high precision used is 5%, then the value of s is 0.05. Calculation formula \( N' \) is as follows:

\[ N' = \frac{k:s\sqrt{N\sum x_i^2 - (\sum x_i)^2}}{\sum x_i} \]  
(7)

If the value of \( N' < N \) then enough data, and if \( N' > N \) then the data is not enough. For example, test the adequacy data smell parameter:

\[ N' = \frac{2/0.05\sqrt{10x143,563 - 37,820^2}}{37,820} = 5,908 \]

The value of \( N' = 5,908 < N \) worth 10, then observations are enough to smell test parameters. The recapitulation of the uniformity test data and test the adequacy of the data for the measurement of all test parameters can be seen in the Table 2.
**Table 2. Recapitulation Of Uniformity Tests And Test The Adequacy Of Data**

| The Operator | Test Parameters | Test the uniformity of data | Test adequacy of data |
|--------------|-----------------|-----------------------------|------------------------|
| A            | Smell           | Average | BKA | BKB | Description | N | N | Description |
|              |                 | 3.782   | 4.266 | 3.298 | Uniform | 5.908 | 10 | Enough |
|              | BOD             | 5371.650 | 5487.383 | 5255.917 | Uniform | 0.149 | 5 | Enough |
|              | Conductivity    | 10.924  | 11.724 | 10.124 | Uniform | 1.930 | 10 | Enough |
|              | Turbidity       | 40.367  | 42.359 | 38.375 | Uniform | 0.876 | 10 | Enough |
|              | Dissolved Oxygen| 31.706  | 34.152 | 29.260 | Uniform | 2.041 | 7 | Enough |
|              | Slurries Dissolves | 22.184 | 24.807 | 19.561 | Uniform | 4.474 | 5 | Enough |
|              | pH              | 36.313  | 40.313 | 32.313 | Uniform | 4.367 | 10 | Enough |
|              | Taste           | 3.344   | 3.846 | 2.842 | Uniform | 8.119 | 10 | Enough |
|              | Temperature     | 9.573   | 10.294 | 8.852 | Uniform | 1.891 | 6 | Enough |
|              | Total Solid Suspension (TSS) | 850.360 | 929.255 | 771.465 | Uniform | 3.099 | 10 | Enough |
|              | Color           | 33.873  | 36.761 | 30.984 | Uniform | 2.181 | 4 | Enough |
|              | Organic Substances | 36.948 | 40.488 | 33.407 | Uniform | 3.213 | 8 | Enough |
|              | Fluoride (F)    | 104.890 | 109.837 | 99.943 | Uniform | 0.712 | 5 | Enough |
|              | Oil and Fat     | 1622.963 | 1645.762 | 1600.164 | Uniform | 0.068 | 7 | Enough |
|              | NH3-N           | 273.453 | 292.928 | 253.977 | Uniform | 1.522 | 4 | Enough |
|              | Nitrate (NO3)   | 228.569 | 231.422 | 225.704 | Uniform | 0.042 | 3 | Enough |
|              | Nitric (NO2)    | 76.054  | 78.766 | 73.342 | Uniform | 0.407 | 5 | Enough |
|              | Nitrogen Total  | 859.238 | 885.643 | 832.834 | Uniform | 0.315 | 6 | Enough |
|              | Phosphate (PO4) | 114.963 | 121.306 | 108.620 | Uniform | 0.812 | 3 | Enough |
|              | Cyanide (CN)    | 197.808 | 209.394 | 186.223 | Uniform | 1.143 | 6 | Enough |
|              | Sulfate (SO4)   | 101.205 | 107.182 | 95.228 | Uniform | 1.046 | 4 | Enough |
| C            | Alkalinity      | 40.778  | 44.659 | 36.896 | Uniform | 2.718 | 4 | Enough |
|              | COD             | 178.137 | 199.334 | 156.940 | Uniform | 5.097 | 10 | Enough |
|              | Calcium (Ca)    | 91.240  | 98.881 | 83.599 | Uniform | 2.244 | 5 | Enough |
|              | Hardness        | 27.786  | 30.016 | 25.556 | Uniform | 2.061 | 5 | Enough |
|              | Chloride (Cl)   | 30.240  | 32.584 | 27.896 | Uniform | 1.922 | 5 | Enough |
|              | Magnesium (Mg)  | 89.410  | 92.079 | 86.741 | Uniform | 0.238 | 3 | Enough |
|              | Salinity        | 42.747  | 45.926 | 39.567 | Uniform | 1.475 | 3 | Enough |
|              | Silica (SiO2)   | 430.347 | 432.281 | 428.413 | Uniform | 0.005 | 3 | Enough |
|              | Mercury (Hg)    | 142.427 | 145.972 | 138.881 | Uniform | 0.165 | 3 | Enough |
|              | Arsan (As)      | 147.354 | 154.263 | 140.445 | Uniform | 0.704 | 5 | Enough |
|              | Iron (Fe)       | 135.893 | 140.699 | 131.088 | Uniform | 0.333 | 3 | Enough |
|              | Cadmium (Cd)    | 138.106 | 144.889 | 131.323 | Uniform | 0.844 | 8 | Enough |
|              | Chrome l        | 126.300 | 132.220 | 120.380 | Uniform | 0.659 | 4 | Enough |
|              | Cobalt (Co)     | 143.237 | 150.502 | 135.972 | Uniform | 0.686 | 3 | Enough |
|              | Potassium (K)   | 132.778 | 142.304 | 123.252 | Uniform | 1.647 | 5 | Enough |
|              | Mangan (Mn)     | 136.608 | 142.745 | 130.472 | Uniform | 0.673 | 6 | Enough |
|              | Nickel (Ni)     | 127.836 | 137.564 | 118.108 | Uniform | 1.853 | 5 | Enough |
|              | Zinc(Zn)        | 128.837 | 135.088 | 122.586 | Uniform | 0.807 | 7 | Enough |
|              | Copper (Cu)     | 134.909 | 141.592 | 128.225 | Uniform | 0.841 | 7 | Enough |
|              | Lead (Pb)       | 134.745 | 142.016 | 127.474 | Uniform | 1.019 | 8 | Enough |
| D            | Total Coliform  | 4558.853 | 4720.732 | 4396.973 | Uniform | 0.378 | 4 | Enough |
|              | E.coli          | 17064.550 | 17193.260 | 16935.840 | Uniform | 0.015 | 3 | Enough |
|              | Number Total Fins | 2275.870 | 2315.589 | 2236.151 | Uniform | 0.081 | 3 | Enough |
|              | Boron           | 88.137  | 89.418 | 86.855 | Uniform | 0.056 | 3 | Enough |

The formula to find the normal time:

\[ W_n = W_s \times p \]  

(8)
Where:
Wn = the normal Time
Ws = cycle times
p = adjustment factor, if p = 1 working fair, p<1 working too slowly and p>1 working too fast.
The formula to find standard time:

\[ Wb = Wn \times (1 + All) \]  
(9)

Where:
Wb = Time raw material/standard
Wn = the normal Time
All = Allowance
Recapitulation Result of standard time for all test parameters can be seen in Table 3.

| The Operator | Test Parameter | Cycle Time (minutes) | p  | Normal Time (minutes) | (1+All) | Standard Time (minutes) |
|--------------|----------------|----------------------|----|-----------------------|---------|------------------------|
|              | Smell          | 3.782                | 1  | 3.78                  | 1.11    | 4.20                   |
| BODE         | 5371.650       | 5371.65              | 1  | 5371.65               | 1.11    | 5962.53                |
| Conductivity | 10.924         | 10.92                | 1  | 10.92                 | 1.11    | 12.13                  |
| Turbidity    | 40.367         | 40.37                | 1  | 40.37                 | 1.11    | 44.81                  |
| Dissolved Oxygen | 31.706   | 31.71                | 1  | 31.71                 | 1.11    | 35.19                  |
| Slurries Dissolves | 22.184   | 22.18                | 1  | 22.18                 | 1.11    | 24.62                  |
| pH           | 36.313         | 36.31                | 1  | 36.31                 | 1.11    | 40.31                  |
| A  | Taste         | 3.344                | 1  | 3.34                  | 1.11    | 3.71                   |
| Temperature  | 9.573          | 9.57                 | 1  | 9.57                  | 1.11    | 10.63                  |
| Total Solid  | 850.360        | 850.36               | 1  | 850.36                | 1.11    | 943.90                 |
| Dud pension  (TSS) | 33.873     | 33.87                | 1  | 33.87                 | 1.11    | 37.60                  |
| Color        | 36.948         | 36.95                | 1  | 36.95                 | 1.11    | 41.01                  |
| Organic Substances | 104.890  | 104.89               | 1  | 104.89                | 1.13    | 118.53                 |
| Fluoride (F) | 1622.963       | 1622.96              | 1  | 1622.96               | 1.13    | 1833.95                |
| Oil and Fat  | 273.453        | 273.45               | 1  | 273.45                | 1.13    | 309.00                 |
| NH3-N        | 228.563        | 228.56               | 1  | 228.56                | 1.13    | 258.28                 |
| Nitrate (NO3) | 76.054        | 76.05                | 1  | 76.05                 | 1.13    | 85.94                  |
| Nitrogen Total | 859.238      | 859.24               | 1  | 859.24                | 1.13    | 970.94                 |
| Phosphate (PO4) | 114.963      | 114.96               | 1  | 114.96                | 1.13    | 129.91                 |
| Cyanide (CN) | 197.808        | 197.81               | 1  | 197.81                | 1.13    | 223.52                 |
| Sulfate (SO4) | 101.205        | 101.21               | 1  | 101.21                | 1.13    | 114.36                 |
| Alkalinity   | 40.778         | 40.78                | 1  | 40.78                 | 1.31    | 53.42                  |
| COD          | 178.137        | 178.14               | 1  | 178.14                | 1.31    | 233.36                 |
| Calcium (Ca) | 91.240         | 91.24                | 1  | 91.24                 | 1.31    | 119.52                 |
| Hardness     | 27.786         | 27.79                | 1  | 27.79                 | 1.31    | 36.40                  |
| Chloride (Cl) | 30.240        | 30.24                | 1  | 30.24                 | 1.31    | 39.61                  |
| Magnesium (Mg)| 89.410        | 89.41                | 1  | 89.41                 | 1.31    | 117.13                 |
| Salinity     | 42.747         | 42.75                | 1  | 42.75                 | 1.31    | 56.00                  |
| Silica (SiO2) | 430.347        | 430.35               | 1  | 430.35                | 1.31    | 563.75                 |
| Mercury (Hg) | 142.427        | 142.43               | 1  | 142.43                | 1.31    | 186.58                 |
| Arsen (As)   | 147.354        | 147.35               | 1  | 147.35                | 1.31    | 193.03                 |
| Iron (Fe)    | 135.893        | 135.89               | 1  | 135.89                | 1.31    | 178.02                 |
| Cadmium (Cd) | 138.106        | 138.11               | 1  | 138.11                | 1.31    | 180.92                 |
| Chrome l     | 126.300        | 126.30               | 1  | 126.30                | 1.31    | 165.45                 |
| Cobalt (Co)  | 143.237        | 143.24               | 1  | 143.24                | 1.31    | 187.64                 |
|                  |      |      |      |      |
|------------------|------|------|------|------|
| Potassium (K)    | 132.778 | 1  | 132.78 | 1.31 | 173.94 |
| Manganese (Mn)   | 136.608 | 1  | 136.61 | 1.31 | 178.96 |
| Nickel (Ni)      | 127.836 | 1  | 127.84 | 1.31 | 167.47 |
| Zinc (Zn)        | 128.837 | 1  | 128.84 | 1.31 | 168.78 |
| Copper (Cu)      | 134.909 | 1  | 134.91 | 1.31 | 176.73 |
| Lead (Pb)        | 134.745 | 1  | 134.75 | 1.31 | 176.52 |
| Total Coliform   | 4558.853 | 1  | 4558.85 | 1.11 | 5060.33 |
| E.coli           | 17064.550 | 1  | 17064.55 | 1.11 | 18941.65 |
| Number Total Fins| 2275.870 | 1  | 2275.87 | 1.11 | 2526.22 |
| Boron            | 88.137 | 1  | 88.14  | 1.11 | 97.83  |

4. Conclusion
Test parameters that have the largest time is E. coli namely 18941.65 minutes = 315.69 hours = 13 days, so if the customer wants to test E. Coli then the minimum standard of services testing of liquid waste is 13 days, if there is no testing of e. coli, minimum standard of services remain 9 days.

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