Statistical Process of Results and Laboratory Proficiency Evaluation of Proficiency Testing

Abstract: This paper introduced the statistical procedure of proficiency testing, calculation method and details in laboratory proficiency evaluation of plastic packaging material barrier property testing organized by CNCA. Labthink participate in the project as cooperating institute.

Key Words: oxygen transmission rate, water vapor transmission rate, proficiency testing, data statistic, outlier

CNCA organized the "Barrier property test of plastic packaging material——Determination of oxygen and water vapor transmission rate" around China in 2007, the result will be announced recently. Labthink engaged in the result statistic as the one and only cooperating institute. This paper introduced the statistical processing method of proficiency testing and laboratory proficiency evaluation in details.

1．Brief introduction of data statistic

The data statistical process of proficiency testing of plastic packaging material barrier property, which adopt the result processing method of laboratory proficiency testing program CNAS-GL02《Guidance on Statistic Treatment of Proficiency Testing Results and Performance Evaluation》, evaluating the proficiency of laboratories took part in the project by robust statistical method.

CNAS-GL02 which include inspecting and result processing of proficiency testing interlaboratory and within-laboratory, direct the result statistical process of CNAS's proficiency testing and the way of evaluate laboratory proficiency by statistical processing result. The statistical procedure, which inspecting result processing method of proficiency testing interlaboratory, can be applicable to majority of proficiency testing. Result analysis had better adopt these procedures if possible. When we estimate laboratory proficiency based on the result of proficiency testing, we use the words "satisfy/dissatisfy" or "outlier" instead of "passed". If a result is considered to be outlier, that is to say it is quite different from other result in the group in statistic.

2．Introduction of statistical method

The premise of statistical analysis is the analysis result under assumption of normal distribution. Normal distribution is most common types of statistical distribution, organizers, especially experts must notice that all the result follow normal distribution approximatively. Before statistical analysis, possible measures must been done to ensure the correctness and reasonability of collected data. We must inspect data carefully and recognize the gross errors and potential problems.

2.1Statistic sum up

The seven comprehensive statistic data below must be computed in statistical procedure. It is the premise of laboratory result statistical evaluation.

1. Fruit number, the total of result gained from a specific test, the symbol is N.

2. Median, the intermediate value of a group of data. If N is odd number, median is a center value, that is

$X\dfrac{[(N+1)]}{2}$. If N is even number, median is the average of two center values, that is $\dfrac{(X[N/2] + X[(N/2)+1])}{2}$.

3. Standard IQR, the measurement of result variability, equal to IQR multiply 0.7413 (0.7413 is derived from standard normal distribution). The IQR is the difference between the high quartile and the low quartile.

4. Robust CV, is coefficient of variation, $\text{robust} CV = \dfrac{\text{standard} IQR}{median} \times 100\%$

5. Minimum, the lowest value, $X[1]$

6. Maximum, the highest value, $X[N]$

7. Range, the difference between minimum and maximum.

The most important statistical value is median and standard IQR, they are the degree of concentration and distribution of data. Median and standard IQR are robust statistics, they are not influenced by outliers.

2.2 Result of statistical sample pairs

Using Z-score based on robust total statistics (median and standard IQR) to evaluate the result from laboratories participating in the project. In order to statistic the result of sample pair A and B, we must have two Z-score, the interlaboratory Z (ZB) and within-laboratory Z (ZW). They are the standard sum (S) and standard difference (D) depending on result pairs.

$$S = \frac{(A+B)}{\sqrt{2}} \qquad D = \frac{(A-B)}{\sqrt{2}} \quad \text{（keep the sign of D）}$$

Through the calculation of standard sum (S) and standard difference (D), we can get median and standard IQR of all S and D, then we can compute the ZB and ZW.

$$ZB = \frac{S - median(S)}{\text{standard} IQR(S)} \qquad ZW = \frac{D - median(D)}{\text{standard} IQR(D)}$$

2.3 Experimental result evaluation

Evaluating experimental results by Z-score (ZB and ZW). The absolute value Z is larger than or equal to 3, result or result pair is outlier. $2 < |Z| < 3$, result or result pair is suspiciousness. A positive outlier (ZB≥3) of even pairs and split level pairs indicate that the value of sample pairs is too large. A negative outlier (ZB≤3) indicates that the value of sample pairs is too small. An outlier ($|ZW|$≥3) within-laboratory demonstrates that the difference between two results is too large.

Sequence diagram of Z-score is used to explain the statistical condition of results. Z-score of each laboratory is illustrated in orders and the laboratories numbers are marked out in figure, which made it is easy to compare different laboratories. Other methods such as Youden's figure are also in common use.

Especially, late arrival results and results from supplement testing are not been put in the general statistic but are given result evaluation according to the first-turn general statistic.

3．Proficiency testing and data statistic

The proficiency testing "Barrier property test of plastic packaging material——Determination of oxygen and

water vapor transmission rate", designs samples with "split level" and divides them into two groups, A and B. ZB and ZW are used in data statistic. In the proficiency testing, 69 laboratories took part in oxygen transmission rate testing, 61 of them offered available testing data. 67 laboratories participated water vapor transmission rate testing, 66 of them offered available testing data. On summary of the testing methods, totally 10 laboratories did not use gravimetric method (cup method) in water vapor transmission rate testing, 6 of them using infrared sensor method, 4 of them using electrolysis sensor method. 16 laboratories did not using differential-pressure method in oxygen transmission rate testing, 13 of them using equal-pressure method - oxygen sensor method.
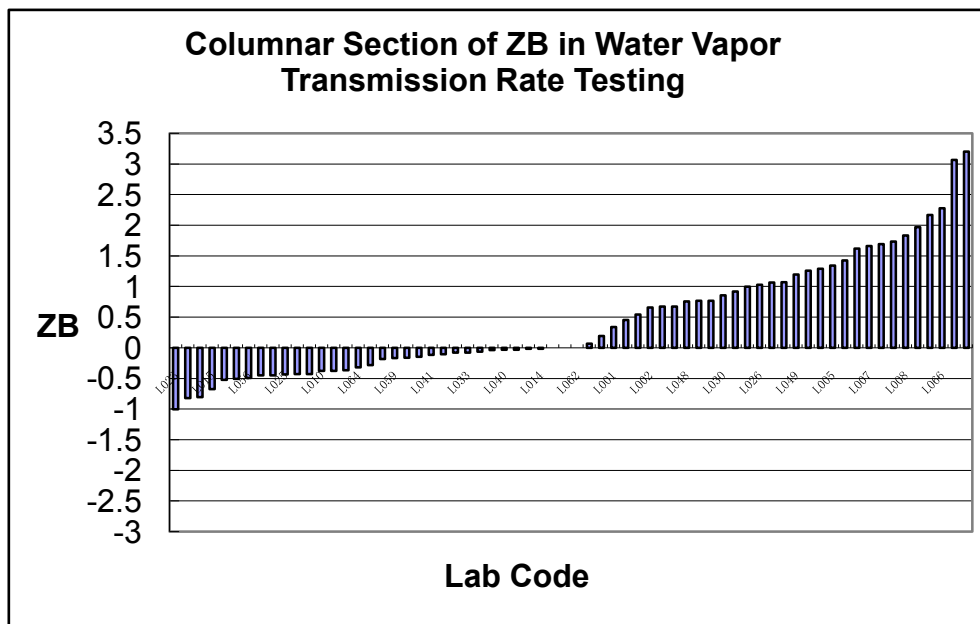

Figure1. Columnar section of ZB in water vapor transmission rate testing

Sequence of Z-score of the first total water vapor transmission rate testing is illustrated in Figure 1, we have a general glance of testing data of laboratories engaged in the project. 2 laboratories that are considered to be outliers, did not adopt the suggested method - gravimetric method. We cannot introduce the within-laboratory Z (ZW) of water vapor transmission rate testing and statistic of oxygen transmission rate testing for space restriction.

We can see from the first total statistic of testing data that none of laboratories using gravimetric method and differential-pressure method are considered to be outlier, the systematic error of instruments is within the allowable range of national. Statistical data affirmed the basic station of gravimetric method and differential-pressure method.