

## Gas Permeability Tester of Differential-Pressure Method Highly Improved in Efficiency

**Abstract:** this article analyzes the factors influencing test efficiency during auto gas permeability test. It concludes that it is the number of specimen that is the key factor affecting test efficiency. And there should be no obvious differences between vacuum method and sensor method in terms of test time. Based on Labthink VAC-V2, this article also elaborates on the improvements and great achievements being made in enhancing test efficiency of gas permeability test instruments.

**Keywords:** differential-pressure method, gas permeability, and test efficiency

Differential-pressure method is the basic way of gas permeability test while vacuum method is the most widely used one in differential-pressure method. In the past, test precision and test efficiency of this instrument is restricted by previous technology and key components. Hence differential-pressure method instruments were considered as 'low precision and worse efficiency'. With the improvement of test technology, test precision of differential-pressure method instruments has been greatly improved and can reach 0.01 ml/m<sup>2</sup>·24h·0.1Mpa now. Comparing with equal pressure method, its test efficiency is also improved. However, the popularity of barrier property test instruments and the increasing test demand bring up higher requirements to test efficiency of current test instruments. Based on the characteristics of differential pressure test, this article analyzes the improvement of test efficiency and introduces corresponding achievements being made.

### 1. Factors Influencing Test Efficiency

Lower efficiency is one of the common comments on previous differential pressure method instruments, which reveals two main shortcomings of the differential pressure method instruments: longer test time and limited number of specimen. These two factors directly restrict the improving of test efficiency. Therefore, to improve test efficiency, test time should be shortened or specimen number should be increased.

#### 1.1 Test Time

Test time of vacuum method, the representative method of differential-pressure method, includes evacuation time and equilibrium time of transmission. Empirical tests have proved that extremely short evacuation time affects test results. There are two aspects accounting for the influence. On the one hand, exhausted gas of vacuum pipeline during test process is calculated as test gas transmitting specimen (pressure sensor is unable to distinguish the type of gas). Therefore, test data appears to be bigger and test data is not stable. On the other hand, although the material has been preprocessed, there are still impurities existing on its surface and some gases transmitting into impurities. The length of evacuation time has influences on such impurities and the eliminating difficulty of the gases inside. The longer the evacuation time is, the better the eliminating effect and the more stable the test data will be. It has been proved that pressure maintaining appears to be more difficult if evacuation time is less than five hours. Therefore evacuation time is specified to be longer than five hours in relating standards. In GB 1038, evacuation should continue for more than three hours even if evacuation system has reached the requirement of standards.

Test time sensor method, the representative method of equal pressure way, is divided into system purging time and equilibrium period. There is clear requirement on purging time in relating test standards and it has been emphasized in many materials that this purging time can never be very short. Moreover, in standard ASTM D 3985-05, purging time is divided into dehumidification time and zero purging time, which is about the same with that of vacuum method. In developing test instruments of oxygen sensor method, Labthink has conducted studies

on the reasonable purging time of system. According to its study, to begin the test, pre-purge two hours and then guide carrier gas into the sensor to continue purging for 24 hours. Now oxygen content of inner system can be considered as lower enough to begin test.

It can be seen that preparation time (evacuation time of vacuum method and purging time of sensor method) before transmission equilibrium in these two methods is similar. As to the time to establish transmission equilibrium, gas permeability of specimen becomes the key factor. Ambient conditions will exert obvious influence on the establishing of transmission equilibrium. Temperature variation has the most obvious influence on equilibrium process. The more severe the temperature fluctuation is, the longer the equilibrium time will be. Consequently, the worse the data repeatability and the lower the accuracy are. It should be noted that environment variation would affect gas permeability test of any method, differential pressure method and equal pressure method are of no exception. The extent to which it is affected varies with specific test method. Therefore, the function of stable temperature and humidity controlling of gas permeability test instruments can greatly facilitate data stability.

In summary, test time consumed of the above two methods are basically the same. It is not correct for some documents to consider test time of equal pressure method as shorter.

## 1.2 Specimen Number

As stated above, it is rather difficult to improve test efficiency only by shortening test time. Test efficiency can be greatly improved if more specimens can be tested within one period. However, gas permeability test of material is a kind of microcosmic test. Sealability of test system is the reliable basis for evaluating instrument precision and data reliability. When the number of specimen is more than one, leakage probability of system is much higher than that of instruments testing only one specimen. System leakage imposes much higher influences on vacuum method than on sensor method. In vacuum method, one side of the specimen remains vacuum state. The sensor only tests pressure, unable to distinguish gases. If System leakage appears, the evaluation will be of no significance and in turn results in test failure. Comparing with vacuum method, Test principle of sensor method is obviously difficult. Even there is little system leakage, the influence will be much more smaller. But when specimens of high barrier property are tested, this influence is rather obvious. Though instruments possessing test function of combined chambers have great advantages, vacuum method instrument having this function is a blank in the market. However, increasing the number of specimens can greatly improve test efficiency. It is in this aspect that differential pressure method instrument has the advantage and enjoys the evaluation of 'higher test efficiency'.

## 2. The Improvement Made by Labthink VAC-V2

According to the above analysis, to realize the vacuum condition required in vacuum method test with current technology, evacuation time couldn't be less than five hours. Thus shortening equilibrium time becomes the only way to shorten test time. Similar to what stated in precious part, test time depends on objective conditions of specimen. The stability of test temperature can also exert influence to this time. Therefore test time can be shortened to some extent by improving temperature stability. Though vacuum method instruments with self-temperature controlling function have expanded all over the world, the controlling range and precision are not ideal. The commonly used way of temperature controlling is the temperature raising controlling and constant temperature protection in the big environment of test instruments including test chambers. At present, the effect of this way is not ideal. First, in addition to lower temperature precision, the bigger controlling environment is not good for uniformity of gas temperature inside. Next, it is very difficult to lower the temperature of test chambers. With its external temperature controlling system, Labthink VAC-V2 can rapidly increase the temperature of test

chambers with high precision, with which the efficiency of temperature controlling is greatly improved. At the same time, VAC-V2 reduces the controlling area and greatly raises the uniformity of chamber temperature. With its temperature precision up to  $\pm 0.1^{\circ}\text{C}$ , the error between measured temperature and temperature inside chambers can be avoided.

Labthink VAC-V2 overcomes the technical difficulties of instrument structure. It can simultaneously test three different specimens automatically, providing test data of individual specimen, by which test efficiency is at least two times that of single chamber test. As stated previously, evacuation time of vacuum method is very important and cannot be omitted or shortened at will. Generally, a period of eight hours can satisfy the requirement of any specimen. The time for establishing transmission equilibrium can be directly affected by properties of specimen. If test temperature is stable, the equilibrium time only depends on the nature of transmission gas and specimen. Now there are three at hand specimens and are named A, B, and C respectively: A refers to specimen with lower barrier property and the time needed to establish transmission equilibrium is about one hour; B refers to specimen of medium barrier property with the equilibrium time being about five hours; C refers to specimen of high barrier property and the transmission equilibrium time is about 9.5 hours or 13 hours. However, when VAC-V2 is used to test the three specimens, all the results will be obtained within 13 hours, with Test efficiency being improved about 1.4 times. If VAC-V2 is used to test three specimen of similar barrier property, test efficiency can increase about two times, which is not inferior to multiple-chamber instruments. In addition, VAC-V2 test chamber has excellent sealability. It is possible to shorten evacuation time if the ability of evacuation system is raised. Therefore VAC-V2 still has follow-up capability of test efficiency.

### 3. Conclusion

As the basic method of gas permeability test, vacuum method has always been the mostly widely used one. However, low efficiency has always been a choke point of this test method. At present, with the success of multiple-chamber test technology, vacuum method instruments have more advantages than multiple-chamber sensor method instruments in terms of test efficiency. Test instruments of Vacuum method now can completely meet the actual demand of heavy test tasks, which paved the way for its arbitration position.