

Misunderstanding Concerning Test Efficiency of Differential-pressure Method and Equal-pressure Method

Abstract: this article analyses test duration of gas permeability test and concludes that system purge time should be included into test duration. It is not correct only taking evacuation time of differential-pressure method into account while neglecting purge period of equal-pressure method. At the same time, this article introduces the factors affecting transmitting equilibrium.

Key Words: gas permeability, test efficiency, system purge

Some people hold that equal-pressure method is superior to differential-pressure method in terms of test efficiency, which proves to be incorrect. Such opinion correlates with people's misunderstanding about test duration and test efficiency of gas permeability testing. This article analyzes test efficiency of gas permeability testing based on the characteristics of the test. Based on current testing technology, this article also analyzes test efficiency of differential-pressure method and equal-pressure method.

1. How to Calculate Efficiency of Gas Permeability Test

Test duration must be made clear before evaluating efficiency of specific test method. Differing from other physical testing, in addition to the state adjustment of specimen, gas permeability testers also require regulation time, which includes both warm up time of instruments and purge time of system. No matter what measures are adopted, the pollution of test cells and gases inside gas pipeline resulting from specimen attachment cannot be avoided. Gas impurity (non-test gas) will influence gas transmission process of specimen and in turn affects test results. Therefore, prior to gas transmission, gas impurity must be removed from test cells and gas pipeline.

How does system purge time relates with test duration? This problem is the root of people's wrong opinion concerning efficiency of gas permeability test, i.e. having no explicit definition of test duration, thus whether purge time should be concluded into test duration becomes optional. For example, evacuation time of differential-pressure method is taken into account while purge time of equal-pressure method is excluded. Test duration of gas permeability test should include system purge time and the time to set up transmission equilibrium. Test efficiency should not be evaluated only by comparing test duration of equal-pressure method with the time sum of test duration and evacuation time of differential-pressure method.

1.1 Purge Time

Different test methods adopt different system purge modes. For example, in differential-pressure method, test cells and relevant pipeline are evacuated. In equal-pressure method, carrier gas with big flow is used to purge test cells and gas pipeline. Therefore, purge time of different methods vary with each other. For differential-pressure method, system purge time is the evacuation period before transmission process begins. While for equal-pressure method, it is the purge time of carrier gas (generally nitrogen gas is used) to purge the whole test cells and gas pipeline before feeding test gas.

Long term tests have proved that in differential-pressure method, the volume of test cell is in direct proportion to evacuation period. Evacuation period is also specified in standards. It is specified in GB/T 1038 that evacuation should continue for three hours after the required vacuum degree is reached. It is clearly specified in equal-pressure method standards that purge time relates with material and thickness of specimen. Moreover, in ASTM D3985-05, purge time is divided into dehumidifying time and zero purge time. In many documents, it is stated that this time will in no way be short and is generally about the same with that is needed in

differential-pressure method. Labthink has conducted research on reasonable system purge time during its development of equal-pressure method permeability testers. The study proves that oxygen concentration of inner system can be considered as extremely low when carrier gas has been diverted into the sensor and has kept purging for 24 hours. Such purge can secure ideal effect and accurate test results. It can be seen from previous analysis that for the majority of polymer materials, system purge time is longer than the time needed to set up transmission equilibrium.

To improve test efficiency, some people propose to shorten purge time. What influences will be brought by the gas impurity resulting from shorter purge time. Labthink set up a research subject in connection with shortening purge time. First, shorten the purge time of equal-pressure method and the evacuation period of differential-pressure method. Then compare the measured results with results obtained from standard test procedures. According to the comparison, in differential-pressure method, transmission equilibrium period demonstrates no obvious changing with the shortening of evacuation time while test data appears an increase tendency. Tests of higher barrier materials are more obviously influenced than that of medium and lower barrier material. In equal-pressure method, shortening purge time prolongs the period to set up transmission equilibrium with obvious lower data repeatability. Reasons for the above situations are analyzed as below: in differential pressure method, due to the influences of evacuation time, test cells and gas pipelines do not reach ideal purge effect due to the existing of gas impurity inside. Gas impurity affects transmission process of carrier gas and results in bigger test results with lower data stability. For equal-pressure method, shortening purge period results in incorrect zero point determination. In addition, the shortening of purge time makes some gas impurity exist inside system, which can only be taken away by later test gas. Therefore, the time needed to set up transmission equilibrium will be obviously increased. That is why shortening purge time cannot shorten the whole test duration.

1.2 Time Needed to Set up Transmission Equilibrium

The time needed to set up transmission equilibrium is also the time used to test gas permeability of specimen, that is, from the ending of previous procedure until the equilibrium of transmission. This time period depends on gas permeability of specimen. When the same kind of material is tested using differential-pressure method and equal-pressure method, the time needed to set up transmission equilibrium is very close. Generally, the principle below is followed: for low barrier material, a period of about two hours is needed. For medium barrier materials it is 2-6 hours and for high barrier materials, a period of 6 hours is usually needed.

In actual tests, transmission equilibrium should be determined according to certain conditions to provide test data. However, the time needed to set up transmission equilibrium is greatly affected by environmental factors, especially by temperature variation. The more severe the temperature variation is, the longer the time is needed to set up transmission equilibrium. Correspondingly, test data is lower in repeatability and accuracy. Such environmental variation will affect all methods of gas permeability testing and such affection will not change in different test methods. Therefore, instruments possessing temperature and humidity controlling functions are superior to instruments without such functions in terms of data repeatability and test efficiency.

2. Conclusion

Test efficiency of differential-pressure method instruments is on a par with that of equal-pressure method instruments both in aspects of test methods and in connection with specific tester. Differential-pressure method instruments can satisfy actual test requirements. It is not correct and not practical for some documents to say that test efficiency of equal-pressure method possesses higher test efficiency.