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Air-Tightness Treatment and Performance Analysis of Grain Warehouse in Northeast Region

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Abstract: This paper introduces the geographical location and climate characteristics, warehouse type and quantity of the new stored-grain warehouse since 1998 in northeast region, introduced air-tightness treatment situation, the methods of air-tightness test of the large warehouse and survey of the shallow silo in detail, finally, analyzed air-tightness data, put forward suggestions on warehouse building, air-tightness treatment and method of air-tightness test according to analysis results of air-tightness data.

Key words: warehouse ; air-tightness ; treatment ; test

1 Regional Characteristics

The northeast area of China, includes Liaoning, Jilin and Heilongjiang provinces. This region is situated between 120° – 135° east longitude and 40° – 50° northern latitude, which belongs to the northeast cold and wet ecosystem area in the Chinese stored-grain regions. Its climatic characteristic is that air temperature varies to great extent in spring and autumn, sometimes the change exceeds 10°C each day. In summer, it is very hot in this area with a long sunshine time and plentiful precipitation. The average air temperature is above 15°C. In winter, it is freezing in this area with a short sunshine time. The average air temperature is below 0°C.

2 Grain Warehouse Construction and Air-tightness Treatment

2.1 Grain Warehouse Construction

Northeast region is the major grain-producing area in China, and is known as "Grain Corridor". Therefore, in the 1990s, there were 61 construction projects in the northeastern region among the world bank's projects in our country, the storage capacity came up to 2.369 billion tonnes, which accounted for more than 82% of the total storage capacity of the world bank's project between 1998 to the end of 2002 in the projects of the Central Storing Grain Depot construction, there were 480 construction projects in the northeastern region, the storage capacity came up to 8.418 billion tonnes, which accounted for more than 16.6% of the total storage capacity. In these projects, there are 60 shallow silo items, capacity of storage was 3.89

billion tonnes, which accounted for the storage capacity of 78% of the total shallow silos. Main warehouse types are large warehouse and shallow silo, the main specifications are showed in Table 1.

Table 1.

warehouse type	Specifications (m)	Height of eave(m)
shallow silo	f30 ,f25	14.5 ,17
large warehouse	60 × 27 ,60 × 24	7.8

2.2 Air-tightness Treatment

Main air leakage location, number, air-tight facilities and air-tight materials are shown in Table 2.

Table 2.

Main air leakage location	Number		Main air-tight facilities and air-tight materials
	shallow silo	large warehouse	
doors	1	plastic package slot, plastic film	plastic package slot, plastic film
windows	0	lastic package slot, plastic film	lastic package slot, plastic film
mechanical ventilation window	6	blind plate, rubber pad, bolt	blind plate, rubber pad, bolt
axial fan window	4	air-tight brake gate, plastic package slot, plastic film	air-tight brake gate or plastic package slot, plastic film
circulation fumigation suction pipe	2	air-tight valve	air-tight valve
grain exit	5	air-tight gate	air-tight gate

Main air leakage location	Number		Main air-tight facilities and air-tight materials
	shallow silo	large warehouse	
grain entrance	1	air-tight gate	air-tight gate
entrance above the warehouse	1	blind plate, rubber pad, bolt	blind plate, rubber pad, bolt
natural ventilation window	4	blind plate, rubber pad, bolt	blind plate, rubber pad, bolt
thermometric cable hole	29-31	glass putty, fusion of paraffin and river sand	glass putty or fusion of paraffin and river sand
other punch holes		Concrete, glass putty	Concrete or glass putty

3 Test and Survey on Air-tightness of Warehouse

Air-tightness, which is an important indicator for measuring the level of tightness of grain warehouse under airtight condition, either good or bad, can greatly affect grain storage at a low temperature and pest fumigation effect, it plays an important part in grain safety, so before using new grain warehouse, it's required to achieve the standard named hydrogen phosphide circulation fumigation technical regulations, which says that "the pressure of warehouse should decrease from 500Pa to 250Pa half-life, the time of flat warehouse is no less than 40s, the time of shallow silos and silos is no less than 1 min". We had tested the air-tightness of 105 local large warehouses from October 17th to December 31th in 2001.

Before testing, all of windows and doors were sealed by plastic films and seal layers along the seal groove inside warehouse, plastic films were loose enough to close to doors and windows or inside of anti-bird nets. The doors and windows were then closed; close recirculation fumigation suction pipe and valve of phosphine concentration measuring pipe; according to table 2, all that should be sealed includes mechanical ventilation window, temperature measuring cable pipe, lighting cable pipe and local holes of connection between wall and top of warehouse.

According to air-tightness testing technological picture (Fig. 1), make sure that connecting equipment, instrument and air-tight gate, connection should be sealed and kept not leaking. Start Fans until the pressure inside warehouse up to more than 500 Pa, then quickly close fan and gate, record with a stopwatch when the Manometer reading is at 500 Pa, stop

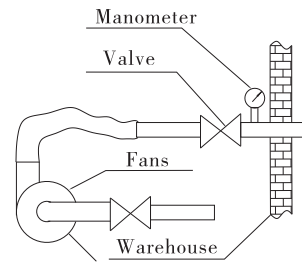


Fig. 1

when the reading is at 250 Pa, repeat the test for three times, record the results separately. During testing, notice that the pressure should not be more than 550Pa, because too much pressure may destroy warehouse; during pressurization, someone should be assigned to observe status of top of the warehouse, if local parts bulge at the top of warehouse, fans and the gate should be immediately closed, and pressurization stopped is required. During pressurization, anyone is prohibited standing outside the doors and windows in order to keep people safe in case that the windows and doors suddenly open.

Early in 2007, our institute gave a survey on the air-tightness of 18 shallow silos in north-east region, treatment method before air-tightness test is shown in table 2, testing methods is the same as that of large warehouse.

4 Results of Test and Survey

Classified statistics is given according to air-tightness data of tested and survey, The results are as follows: the average air-tightness of shallow silos (decrease from 500Pa to 250Pa half-life) are 65 s, the average air-tightness of large warehouse are 48 s.

5 Influencing Factors of Warehouse Air-tightness

5.1 Volume

Through the classified statistics of testing data, the result showed that in the same conditions, generally speaking, air-tightness of large warehouse is better than that of small one. Because to the same height, larger warehouse has larger volume, according to the ideal gas equation $pV = nRT$, it can be deduced that the leakage of air $\Delta n = 250V/RT$ during the pressure decreased from 500Pa to 250Pa, the RT is a fixed number under the same temperature, it is that the air leakage Δn is in direct proportion to the warehouse volume V, the more the volume, the more air leakage during pressure decreases from 500Pa to 250Pa, however, the number of leakage point of the large warehouse is the same

as that of the small one, namely, their air-leakage rate is basically the same, according to time of leakage half-life is equal to the quantities of air leakage divided by air leakage rate, so the half-life of large volume warehouse is longer than that of small volume warehouse.

5.2 Environmental Temperature

During testing, air-tightness of warehouse under high environmental temperature was better than that under low environmental temperature. The reason is that warehouse is usually constructed in summer, the temperature is a little high, when the temperature decreases, leak points can be found uneasily among all parts made up of warehouse, because construction materials expand with heat and contract with cool; at the same time, the environmental temperature, either high or low, impact on the plastic package quality of windows and doors, low temperature leads to poor plastic package quality of the doors and windows.

5.3 Pressure

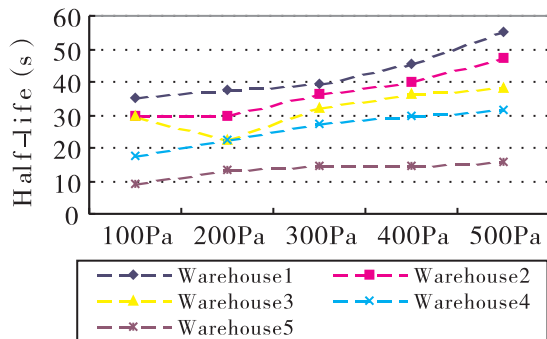


Fig. 2

Test 5 pressure attenuation data of different air-tightness warehouse, the method is that from 500Pa recording the time of 400Pa, 300Pa, 250Pa, 200Pa, 100Pa, 50Pa, until less than 50Pa, then the test data is processed to Fig. 2, Fig. 2. says that for the same warehouse it is showed by one curve, half-life increases as the increase of pressure; for different warehouse, half-life increases as the improve of air-tightness. Half-life of the same pressure of different warehouse is comparable with each other. Local intersect that presents on the curve describes that a few warehouse can bear different pressure in the range of specific pressure, the air in the warehouse leak more or less.

6 Proposal

The structure of all parts of warehouse's top should be constructed according to drawing strictly, especially the sealing construction of connection between panel gap and wall. If treating during late construction or after construction, it needs making facilities for working high above ground, construction will be affected by low temperature, which is hard to treat and will waste lots of human resources and material resources. Therefore, it is hard to achieve the ideal effect.

During the process of constructing warehouse, all kinds of pipes and holes should be sealed anytime. The warehouse is made up of many parts, for example, doors and windows, recirculation fumigation system, mechanical ventilation system, temperature testing system, electrical power distribution system and so on. Each part has different construction units, so it is inevitable to form holes on the body of warehouse. Therefore, each construction unit should be supervised to link up their work and in time plug holes formed after construction. Each units is responsible for itself, workload is small, sealing effect is good.

In order to prevent air leak by tighten too much at blanking plate, the thickness of blanking plate, flanges, pads should not less than 5mm. For reducing weight, when blanking plate is big, the thickness of middle part can be 3mm.

Because of lots of holes on the shallow silo, it is hard to seal, a proposal for adding plastic package slot.

For the warehouse which can not bear 500Pa, it is proposed to test its air-tightness by low pressure half-life, but the standard of air-tightness should less than 500Pa half-life.

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