0704

Introduction of the Technical Regulation for CA Storage of Grain by Purging Carbon Dioxide in China

Wang Shuanglin and Tu Jie

Abstract: The technical regulation for CA storage of grain by purging carbon dioxide in China was made, and the main technical parameters and their proofs were introduced. In the regulation, it is required to remain carbon dioxide concentration above 35 percent for 15 days for complete insect control, and the structures used for controlled atmosphere treatments must have a good gas tightness that corresponds to a decay time of 4 minutes for an applied excess pressure drop of 500 to 250 Pa in a full storage for the process to be effective and economical. The appropriate initial CO_2 concentrations under different gas tightness conditions were also stipulated.

Key words: CO_2, CA storage, technical regulation

1 Preface

Since 2001, 215 million kg capacity storehouses of CA storage of grain by purging carbon dioxide have been built in China. In order to format this technology, reduce the cost and extend it in grain storage practice, we carried out some research and proof-test, and made the technical regulations for CA storage of grain by purging carbon dioxide according to the results from the experiments conducted in China and the existing proved technique. The nomenclature and definition, principle, establishment, equipment, materials, operation requirements and evaluation of this technology were stipulated in the technical regulation.

2 Main Technical Requirements and Their Basis

2.1 Gas Concentrations and Exposure Times to Control insects

Carbon dioxide concentrations and exposure times are the key technical parameters, which have been studied widely and sound in the word. Banks (1979) suggested that an initial level exceeding 70% carbon dioxide and maintained above 35% for 10 days is appropriate for complete insect control at temperatures above 20℃[1]. At temperature decline from 18 to 10℃ or 25 to 20℃, both insects and mites in wheat and barley were killed in less than 2 week at 35% CO_2 concentration (White and Jayas 1993)[2]. Banks and Fields (1995) recommended that when the grain temperature was over 20℃, the duration for carbon dioxide concentration declining from 70% to 35% should reach 15 days for controlling most stored-product insects effectively[2].

The effect of 4 CO_2 concentrations, 25%, 35%, 45% and 80% on controlling four main insects (Sitophilus zeamais, Sitophilus oryzae, Rhyzopertha dominica, Tribolium castaneum) at 25℃ was studied at the laboratory. The result showed that the necessary exposure time for these pests effective control decreased as the CO_2 concentration increased. The result demonstrates that CO_2 concentration declining from initial high concentration to 35% naturally is reasonable and economical (table 1).

Table 1. Required exposure times for complete insect control under different CO_2 concentration.

concentration (%)	times for complete insect control (d)	
	Adult insect	All life stage of insect
35%	≥9	≥15
45%	≥8	≥14
80%	≥3.5	≥12

Experiments were carried out in Shanghai, Jiangxi and Sichuan grain depots in 2005 and 2006 to validate the new technical regulation. The result showed that all insect pests were killed when the CO_2 concentration declining from initial concentration to 35% during 15 days even under 10 – 15℃ conditions. The grain temperature in Shanghai depot was showed in table 2, and the carbon dioxide concentrations in 4 locations were showed in table 3 to table 6.

Chengdu Grain Storage Research Institute 610031

Talble 2. Temperature of grain at No. 82 storehouse in shanghai (℃)

Date	Top layer	Second layer	Third layer	Bottom	Average
2005 – 4 – 7	12.3	10.3	9.5	10.4	10.6
2005 – 4 – 14	13.6	11.6	10.1	11.2	11.6
2005 – 4 – 21	15.2	12.4	10.4	11.5	12.4
2005 – 4 – 28	16.0	13.2	10.8	11.8	13.0

Table 3. Carbon dioxide concentration at No. 82 storehouse in shanghai

Date	Average concentration (%)	Lowest concentration (%)
2005 – 4 – 8	80.0	36.1
2005 – 4 – 10	71.6	52.8
2005 – 4 – 12	62.3	51.3
2005 – 4 – 14	57.3	48.6
2005 – 4 – 18	54.2	48.6
2005 – 4 – 20	51.4	46.3
2005 – 4 – 22	49.3	45.5
2005 – 4 – 25	48.6	44.5
2005 – 4 – 28	42.7	39.3

Table 4. Carbon dioxide concentration at No. 6 storehouse in Jiangxi

Date	Average concentration (%)	Lowest concentration (%)
2005 – 9 – 22	65.93	31.24
2005 – 9 – 23	64.92	47.10
2005 – 9 – 25	58.17	54.61
2005 – 9 – 27	55.68	49.86
2005 – 9 – 29	52.07	47.87
2005 – 10 – 1	50.91	47.04
2005 – 10 – 3	48.26	45.05
2005 – 10 – 5	45.61	43.37
2005 – 10 – 7	43.87	41.60

Table 5. Carbon dioxide concentration at No. 16 storehouse in Sichuan

Date	Average concentration (%)	Lowest concentration (%)
2006 – 6 – 18	85.5	27.1
2006 – 6 – 19	71.2	46.2
2006 – 6 – 20	63.5	52.0
2006 – 6 – 22	55.5	51.1
2006 – 6 – 26	49.9	43.6
2006 – 6 – 28	45.8	40.1
2006 – 6 – 30	42.5	37.3
2006 – 7 – 3	39.8	36.3
2006 – 7 – 4	38.0	35.3

Table 6. Carbon dioxide concentration at No. 12 storehouse in Sichuan

Date	Average concentration (%)	Lowest concentration (%)
2006 – 6 – 9	60.4	27.0
2006 – 6 – 10	57.2	49.0
2006 – 6 – 13	51.0	50.6
2006 – 6 – 16	46.1	44.5
2006 – 6 – 19	44.4	42.8
2006 – 6 – 23	43.8	42.1
06 – 6 – 27	40.6	38.5

2.2 Requirement for Gas Tightness at Grain Storehouse

Good gas tightness of grain storehouse is necessary for the process to be effective and economical. The higher gas tightness, the lower speed of the CO_2 concentration decline. But higher gas tightness also means higher cost for structures. The gas tightness should be suitable to current technique and economic actuality.

The requirement for gas tightness in the technical regulation is that the duration which pressure dropping from 500 to 250 Pa in a full storage is over 240s.

2.2.1 Feasibility in technique

Proof tests were also carried out in Shanghai City and Jiangxi Province in 2005, and in Sichuan Province in 2006. Table 7 showed the CO_2 concentration decline speed under different gas tightness of full storage. The result showed that the carbon dioxide concentration remained above 35% for 15 days economically without supplementing carbon dioxide

Table 7. Concentration decline speed under different gas tightness of full storage

Storehouse	Capacity (t)	Half life of pressure (s)	Initial CO_2 concentration (%)	Concentration decline speed
No. 82 in shanghai	3900	292	80.0	Remain above39% above 20 days

Storehouse	Capacity (t)	Half life of pressure (s)	Initial CO_2 concentration (%)	Concentration decline speed
No. 6 in Jiangxi	2800	330	65.9	Remain above 40% above 15 days
No. 12 in Sichuan	3900	245	85.5	Remain above 35% above 15 days
No. 12 in Sichuan	5200	317	60.4	Remain above 37% above 8 days

2.2.2 Feasibility in current technique and economic actuality

The gas tightness of all carbon dioxide atmosphere controlled storehouses in China was tested in 2005. The capacity of each storehouse is form 2 800 tons to 6 500 tons. The result showed that the half life of pressure of 98% of the carbon dioxide atmosphere controlled storehouses were over 240 s in China in 2005.

So, the requirement on gas tightness in the regulation is feasible in current technique and economic actuality.

Table 8. Number of the storehouse of different gas tightness in China in 2005

Location	Half life of pressure				Total
	<4 min	4 min – 4.5 min	4.5 min – 5 min	>5 min	
Sichuan Province	/	1	7	2	10
Shanghai City	1	2	4	3	10
Jiangsu Province	/	7	4	/	11
Anhui Province	/	/	2	3	5
Jiangxi Province	/	1	2	7	10
Total	1	11	19	15	46
Percentage	2%	24%	41%	33%	100%

2.3 Commendatory Initial CO_2 Concentrations under Different Gas Tightness Condition

It is effective and economical to remain carbon dioxide concentration above 35 percent after 15 days for complete insect control. Superfluous initial carbon dioxide means more cost on carbon dioxide gas, and deficient initial carbon dioxide also costs more because additional carbon dioxide must be added during the storage process. So, in order to make the process to be effective and economical, it is necessary to foreknow the suitable initial CO_2 concentrations under different gas tightness condition.

Initial CO_2 concentrations under different gas tightness condition are recommended in table 9.

Table 9. Recommended initial CO_2 concentrations under different gas tightness condition

Half life of pressure of full storage	Recommended CO_2 concentrations
240	80%
s300	70%
sAbove 360 s	60%

3 Discussion

CA storage of grain by purging carbon dioxide has been applied only 6 years in China. This technique still need to be improved and perfected in practice. It has not been applied on a large scale because of the carbon dioxide provision which causes more cost than phosphine fumigation. But CA storage of grain should have a good future among the storage technology as a green storage technology.

References

[1] E. J. Bond. Fumigation and Controlled Atmosphere Storage. Manual of Fumigation for Insect Control; FAO plant production and protection paper 54. http://www. fao. org/docrep/X5042E/x5042E00. HTM

[2] W. E. Muir, D. S. Jayas, and N. D. G. White. Controlled Atmosphere Storage. (2006 – 03 – 03) http://sci. agr. ca/Winnipeg/storage/pages/presbios_ e. htm

[3] Liu Zuowei, guo Daolin, Yan Xiaoping. Research of CO_2 CA Storage for Controlling Stored – grain Insects. Grain Storage, 2004(2)