Current Situation and Development Tendency of Controlled Atmosphere and Fumigation Technology in Chinese Grain Storage

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Dear Honorific Chairman Banks, Ladies & Gentlemen,

First of all, please allow me to welcome all of you on behalf of Chinese Cereals & Oils Association (CCOA).

Here, I would like to avail myself of this opportunity to briefly introduce Chinese grain storage technologies, especially developments in low temperature grain storage, controlled atmosphere and fumigation technology.

Ⅰ. Chinese grain storage technology has a long history. Research shows that it is at least 7 000 years since our ancestors began to consciously store grain and other seeds. 7 000 years ago in southern China, people used fence-style depots to aerate and store grain; 5 000 yeas ago in central China, people adopted underground vaults to store grain by using matting materials to decrease oxygen content. Records show ancient people began to utilize plant-sources medicines to kill insects in stored grain about 2 000 years ago. From this perspective, China is one of the oldest cradles of low temperature, controlled atmosphere and fumigation technology.

Ⅱ. I will broadly outline the scientific and technological developments on Chinese modern grain storage scientific technologies, and then particularly illuminate the technological developments in low temperature, controlled atmosphere and fumigation.

A. History of Chinese Grain Storage Technology

1. The Chinese government attaches great importance to the development of grain storage science and technology. In the 1950s, China established academic research institutions and began the research in grain storage; in the 60s and 70s, a few middle and high grain schools were established successively which not only cultivated grain intellects but also carried out fruitful researches.

2. China's grain storage facilities were constructed by stages whose capacity is over a few hundred million tons. In the 1990s, China constructed some modern grain storage depots with the loans from the World Bank and China's national debt. These depots are large warehouse, squat silos and vertical silos), which feature large-scale gain bulks, high-level grain layers' (Single depot capacity is 5 000t – 10 000t). In recent years, enterprises' yearly average grain storage capacity totals 1.5 – 2.0 hundred million tons. Farmers' yearly average capacity totals 2.5 – 3.0 hundred million tons. For this reason, China has particularly popularized such technologies as 'grain inspection, machinery aeration, grain cooling and recirculative fumigation' among grain storage enterprises. Not only have China's storage equipment and technologies greatly improved, but also the storage technologies have occupied forefront places in the world.

3. Applied basic theories and applied technologies are the two main aspects of Chinese grain storage research. Depending on our own development experiences and research fruits and using the results of foreign grain storage ecological research, we have summarized a Chinese character grain storage 'ecosystem theory system' to guide grain storage and depot construction in the future. The system includes: reasonable partition of Chinese grain storage ecological zones; reasonable depot types selection and design in different zones; grain depot equipment in different depot types and zones, rational configuration of machinery and special safety-ensuring grain storage equipment for different depot types and zones; the best storage techniques and economic running modes of different kinds of grain in varied depot types and different zones; management and economics evaluation of different storage scales, modes and methods; evaluation indexes and system on safe grain storage technology. Chinese Safe Grain Storage Study researches the tripartite relations among the subject (grains, oil seeds and their products), object (ecological factors including biologic and abiologic) and sociology (management, cost and benefit), which is the development and extension of grain storage study and grain storage ecology.

4. CCOA is a national first-class association whose Storage Branch is an academic organization in which domestic and foreign experts, scholars and a few hundred thousand scientific staffs communicate and cooperate with each other. This branch trains party members and individual member every year, meanwhile, expands cooperation and communication with international academic organizations.

B. Developments in some key fields in Chinese grain storage science & technology. To make this question easy, I will firstly introduce 'ecological grain storage and green grain storage'. 'ecological grain storage' means fully using and controlling the ecological conditions which are favorable to stored grain quality, such as low temperature, low oxygen, therefore ensuring safe grain storage. 'Green grain storage' means trying to adopt technologies that have no contamination on stored grain. The two concepts are consistent to each other. In China, ecological & green grain storage means taking 'low temperature' as the major technology complemented with controlled atmosphere technology in the suitable zones.

1. Low temperature and quasi-low temperature grain storage. In China, the average temperature of grain bulk in the depot below 15℃ with the highest temperature not over 20℃ is called 'low temperature grain storage'; grain bulk's average temperature below 20℃ with the highest temperature not over 25℃ is called 'quasi-low temperature grain storage'. In 2005, China built a large, low-temperature experimental grain depot directly subordinate to the National Grain Reserves in Chengde, Hebei Province. It has a storage capacity of 15 000 tons and its grain storage temperature is controlled below 20℃, which has successfully achieved the designed standards after a few years' operation. Major technological approaches to low temperature and quasi-low temperature are natural low temperature (including overground and underground natural low temperature), machinery aeration, machinery cooling (grain cooling, special cooling machines). From experiment results of nearly 20 national grain depots all over China, machinery aeration in squat silo can effectively decrease stored grain's temperature. In large warehouse, if grain bulk's height is not over 6m, using centrifugal fan, axial-shaft fan and mixed airflow fan could well decrease the temperature and preventing dewing.

Low temperature grain storage technology has brought about corresponding technology research, for example, spray-cooling the exterior of grain depot to reduce temperature, using anti-radiation dope to lower temperature, heat insulation on the ceiling of grain depot to control temperature, different press-top technologies in the grain bulk to insulate heat and keep cool, solar technology to insulate heat and keep cool etc. Based on the previous research of different materials' heat conductibility properties, researchers have proposed the technologies of 'static heat insulation' and 'dynamic heat insulation' for different grain depots of different ecological regions. The grain inspection technology, machinery aeration technology and grain cooling technology have their respective technical regulations.

2. Controlled atmosphere grain storage. In china, controlled atmosphere grain storage research falls into two major phases: the first phase is in the 1960s and 70s, which focused on the study of using different materials for N_2 & CO_2 – filled, or vacuum, small-package storage of grain, edible oil and their processed products; the second phase is from the 1970s when Chengdu Grain Storage Research Institute (CSR) of State Administration of Grain led the development of *Research on Modern Grain Fresh-Keeping Technology*, started comprehensive research on CO_2 controlled atmosphere grain storage technology, and performed small-scale depot experiments. The research explored not only the airtight materials, methods and effects but also the causes of quick deterioration of stored grain under controlled atmosphere after it was exposed to normal air. In 1990s, CSR and Henan Industrial University led the research on the construction of CO_2 controlled atmosphere grain depot. The project was the first time to adopt large-scale system of CO_2 supply, realized centralized CO_2 supply, and developed an automatic depot CO_2 concentration monitoring & analysis system. The longest time of pressure half life of Mianyang depot in Sichuan (air tightness decreases from 500Pa to 250Pa) reaches 12min.

In 2000, after the completion of Sichuan Mianyang CO_2 controlled atmosphere grain depot, some other CO_2 controlled atmosphere grain depots were also constructed in other regions, whose total depot capacity reaches 215 thousand tons.

Since 2005, with the rising of CO_2 price, emphasis is switched to N_2 grain storage. Based on N_2

grain storage demo-application in Jiangsu Nanjing Grain Depot and Guangxi Fangchenggang Grain Depot directly under the National Grain Reserves, the National Grain Reserves invested to build 16 controlled atmosphere depots in a bid to further optimize and expand the demo application. Presently a storage capacity of 320 thousand tons has been put to use, and it is expected to reach 850 thousand tons by the end of 2008.

Besides, the *CO_2 Controlled Atmosphere Grain Storage Technology Regulations* has already been promulgated and brought into effect.

3. Recirculative fumigation technology. From the middle 1960s up to now, the main fumigant in China is phosphine. For this reason, China has deepened the correlated researches which include medical effects (dosage, obturation time and insecticidal effects), factors affecting medical effect (different insect species, different insect states, different temperature, different grain type's adsorption intensity, different obturation conditions and performances, influence of grain bulk's airflow on medicinal effect), different operating methods of fumigation technologies (general fumigation, recirculative fumigation, intermittent fumigation and slow-releasing fumigation) which include the effect-enhancing experiment of phosphine fumigation to decrease O_2 concentration and to increase CO_2 concentration. At the end of 90s, nearly 20 National Grain Depots practical phosphine recirculative fumigation experiments proved that in squat silo and large warehouse recirculative fumigation could force phosphine gas to evenly distribute in the grain bulk and prevent stored grain insects effectively, that the three medicine application methods (using phosphine steel-bottle, recirculative fumigation outside of depot and under-film recirculative fumigation in the depot) have the same effects, and that effects of both one-time and several-time medicine application of under-film recirculative fumigation are affirmed. In practice, technologies of medicine application on grain surface and whole-depot recirculative fumigation, dynamic deliquescence of medicine application at the wind path entrance are also put to use. The total phosphine dosage in China has decreased by 60% after the popularization of recirculative fumigation technology. In addition, the *Phosphine Recirculative fumigation Technology Regulation* has already been promulgated and put into effect.

4. Comprehensively phasing out Methyl Bromide (MB) in grain storage industry.

Supported by U. N. Industry Development Organization (UNIDO), and organized and led by State Administation of Grain and Ministry of Environmental Protection, we have accomplished the MB substitute technology research, realized the goal of phasing out MB in country-wide grain storage industry, and therefore we have fulfilled the Chinese government's magnificent commitment to the international community and have made important contribution to protecting ozonosphere and human's living environment. The main steps are as follows.

Firslty we have confirmed the substitute technology of the industry which has laid foundation for realizing MB phasing outin the industry. Through comprehensive investigation, we have grasped the situation of MB application in grain industry and confirmed that phosphine under-film recirculative fumigation and phosphine and CO_2 mixing fumigation are the main alternative technologies to phase out MB.

We have compiled the training and publicity materials, providing teaching materials for training subprograms and substitute technological expansion and application. We have also compiled *Training Material of Phasing Out MB in Grain Storage Industry*, *Phasing Out MB in Grain Storage Industry Handbook* and *Phasing Out MB in Grain Storage Industry Multimedia Coursebook*.

The third is carrying out technology and management training, enhancing managing and technological personnel's knowledge and skill. Through 6 terms of training, we have completed MB substitute technology training of 387 grain storage managing and technological personnel from 128 units that used MB. We have also organized 2 terms of overseas training program for a total of 20 experts and managing personnel.

The fourth is to equipment configuration and inspection to ensure phasing out achievements. We choose 34 grain depots nationwide as demonstration depots. Through public bidding, we have designated 2 equipment providers in China which provide and install phosphine under-film recirculative fumigation equipment. Meanwhile, we executed 2 phases (4 times) of of on-site inspection of 'equipment providers' supply, installation and commissioning.

The fifth is to promulgate a joint proclamation of forbidding MB, fulfilling our commitment to the international community. Proclamation of *Comprehensively Forbidding MB in Grain Storage In-*

dustry (*No.* 4) jointly promulgated by State Administration of Grain and Ministry of Environmental Protection on 26th of Sep. ,2006 definitely stipulated that 'From 31st of Dec. ,2006, any grain depot of grain storage industry is not allowed to use Methyl Bromide(MB) as fumigant.' The mainstream media hugely publicized and reported the MB phasing out campaign in Chinese grain storage industry In 2007, the total consumption of MB in Chinese grain storage industry decreased to zero, realizing our commitment to the international commitment. The UNIDO, State Administration of Grain and Ministry of Environmental Protection convened a summarizing and commending conference in Beijing in May of 2008.

The sixth is to establish a long-term mechanism of phasing out MB. In order to consolidate the existing achievements, preventing MB grain storage enterprises to reuse MB, we established a long-term, two-layered mechanism: technical assistance and supervision to establish MB phase-out guarantee capability. The long-term mechanism includes the tracking, supervision and evaluation system for MB substitute technology application effects and the supervision and management system.

Ⅲ. Development Tendency in the Future

In the coming 5 – 10 years, with a view to the green, ecological and harmonious development tactics, China will upgrade the traditional grain storage technology, further popularize low temperature and quasi-low temperature grain storage technology in Northern China, promote N_2 and CO_2 controlled atmosphere technology in hot, humid southern China, trying to ensure 60% application of low temperature, quasi-low temperature and temperature controlling technology in grain storage . As for the grain depots that are not suitable to be equipped with the low temperature and controlled atmosphere storage equipment, we will continuously revamp the air-tightness of these depots, in a bid to comprehensively promote phosphine recirculativ fumigation, vigorously carry out research on plant-resources pesticide and biological prevention technology, develop phosphine substitute products, and to minimize dosage of medical agent. We will achieve the goal of 'high quality, high nutrition, high benefit' and 'low waste, low pollution, low cost' in grain storage. At the same time, we shall increase capital investment to improve two hundred million farmers' grain storage conditions step by step and to comprehensively realize scientific grain storage.

Looking to the future, we believe that Chinese grain storage technology will also achieve relatively rapid progress along with modern bio-technology, material technology and information technology.

Thank you very much!