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MAJOR CHANGES IN STORAGE CONSTRUCTION AND THE SAFE STORAGE OF GRAIN IN TIANJIN

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ABSTRACT

Many storage structures have been built over the past decade in Tianjin. In addition to storage there is a requirement for fumigation of stored-products. A modern steel silo complex has been built at the "New Port" to store and treat imported grain. These silos, their equipment, and the technology for their operation were introduced from the U.K. and Germany from 1983-1988. Originally based on gastight bins supplied with aeration systems these silos have been improved by means of five types of fumigation ducting systems developed by the Grain Bureau of Tianjin. Furthermore, a group of fumigation chambers with a capacity of 4,000 m^3 is now under construction to treat wheat mats (termed "tatami" for use in trade with Japan) and other products. This will enable fumigation year-round, including winter. The existence of gastight bins with aeration facilities in this urban area will enable the initiation of controlled atmosphere (CA) treatments.

INTRODUCTION

Tianjin city is a major economic center of northern China and is the gateway to Beijing. It handles the main export and import cargo shipments of the two municipalities of Beijing and Tianjin, as well as several other provinces in north and northwest China. Tianjin city, that spans its four suburbs and five counties, has not only to fulfill the storage requirements of the locally harvested grain, but also storage requirements for the international trade of agricultural products. Plant quarantine activities are carried out routinely (Shungong and Jian, 1986). Development of both industry and agriculture has promoted the construction of modern storage facilities. This paper describes and analyses these developments in Tianjin.

URBAN STORAGE FACILITIES

1. Storage at the "New Port"

This is the sea port of Tianjin situated 50 km from downtown Tianjin and 178 km to the east of Beijing. It encompasses approximately 40 cargo handling terminals, 4 passenger terminals, and one modern grain terminal with an annual unloading capacity of 3.5 million tons. The port facility also comprises 7 large warehouses, and 31 yards for open stacking. The port's 14 modern grain silos, that have a storage capacity of 6,000 tons each, were built during the 1980s. The complete storage structures, their equipment and technology were introduced from the U.K. and Germany. The complex is computerized and operator interfaces have been installed for supervision and control of handling at the terminal elevator and warehouses (see Figs.1-3).

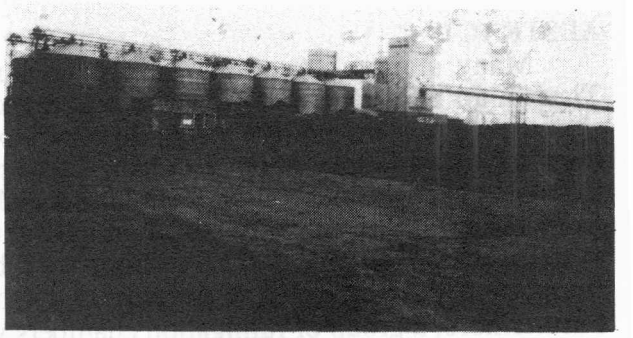

Fig. 1:
General view of storage facilities at the "New Port".

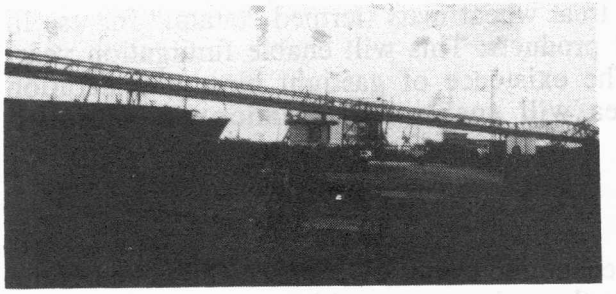

Fig. 2:
The conveyor of the terminal elevator at the "New Port".

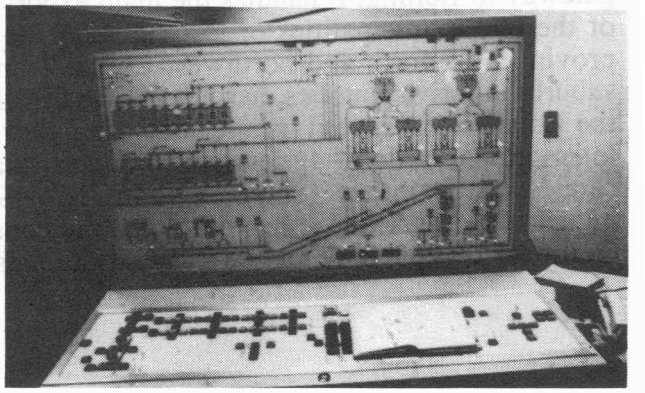

Fig. 3:
The computerized and operator interfaces of storage facilities at the "New Port".

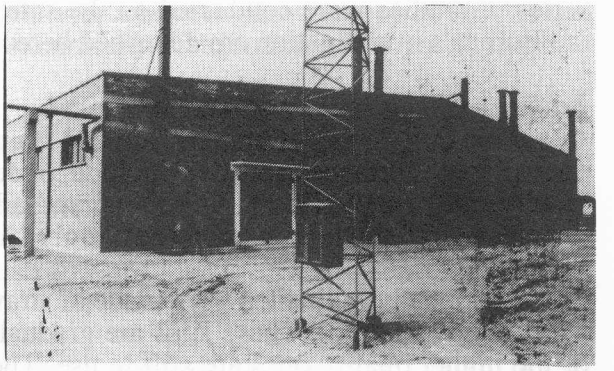

Fig. 4:
Fumigation chamber
for year-round
treatment of imported
and exported stored
-products in Tianjin.

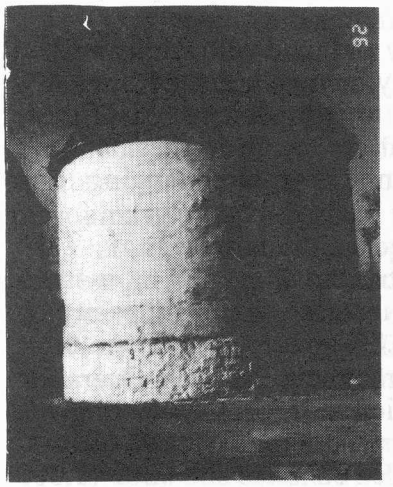

Fig. 5:
A locally-built silo
made of straw
and mud with
white-washed walls.

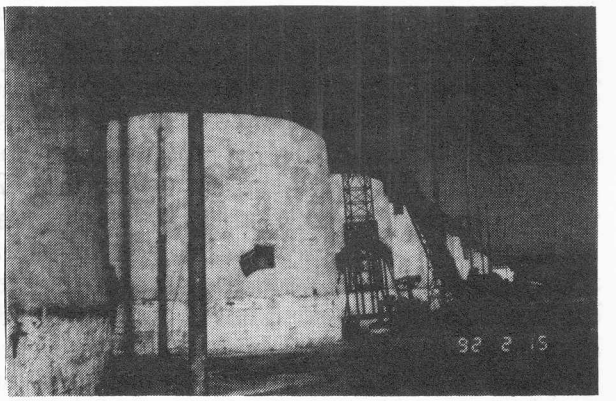

Fig. 6:
A battery of
locally-built silos.

2. Storage for the import and export of stored products

For many years, the vast storage area allocated for the holding of imported and exported stored-product commodities in Tianjin was limited in terms of fumigation capability. Now a group of all-weather fumigation chambers is under construction for the fumigation of wheat mats ("tatami") destined for export to Japan; they will also be used for fumigation of other agricultural products (Fig. 4).

3. Tianjin Grain Bureau activities

Over the past decade, the Tianjin Grain Bureau has invested heavily in the construction of storage structures. Hungarian steel silos were erected using Hungarian technology, and in addition, many large, medium, and small capacity silos made of steel, brick, and reinforced concrete were built by the Bureau. In cooperation with the Tianjin Grain and Oil Institute, a

series of studies were conducted on the safe storage of grain. Findings of the Bureau's investigation are described hereunder.

Junliang Cheng Mill

This mill deals with processing and storage for long-standing business enterprises. Storage facilities include open stacking yards, traditional locally-built small silos, warehouses, and silos made of brick, reinforced concrete, and steel. Ten years ago, only the first three storage systems existed.

The locally-built silos were made of straw and mud with white-washed walls (Figs. 5 and 6). These silos are gradually being eliminated but a few of the higher quality ones are still in use. The total capacity of 51 of these silos is 15,300 tons. Normally rice and wheat are stored in these silos at 11.3-13.0% moisture content (m.c.) with grain temperatures ranging from 1.5-25.5°C throughout the year. The silos may be used to store grain for up to 2 years and in part can be operated using mechanical conveyors.

In 1983, the Junliang Cheng Mill constructed 2 groups of modern reinforced concrete silos to meet the need to increase storage capacity by 30,000 tons. The silos held wheat at 11.9-12.8% m.c., with temperatures ranging from 9.5-21.5°C at the bin centers throughout the year. Operation of these silos was fully mechanized. In addition, a large number of brick silos and steel silos have been built over the past decade. In 1984 a gas-tightness test was carried out in empty reinforced concrete silo #302 (1,000 tons capacity) that had been painted with an acrylic sealant. A positive pressure of 50 mm water was obtained and the half-life pressure decay was not less than 22 seconds. Results of this treatment trial are summarized hereunder:

(1) The silo complied with gastightness standards. Over a 96 hr period monitoring a methyl bromide (MB) fumigation, the mean concentration reached 106.2 g/m^3 and no MB was detected outside the bin. Consequently, the silo was considered suitable for use as a fumigation silo.

(2) Due to the radial position of the fumigation distribution ducts laid at the base of the silo, the fumigation could be undertaken by closed recirculation, thereby ensuring 100% insect kill.

(3) Fumigation by this system was much cheaper than stack fumigation in the yards, with a saving of 10.12 Yuan per ton[1].

(4) Comparison with stacking-yard fumigation show that closed recirculation is advantageous in terms of expediency and safety. Only 7-10 min were required to deliver 50-60 kg MB.

[1]Silo fumigation using this system costs 0.64 Yuan/ton. The alternative to this system would be to unload the grain from the silo manually, bag it in gunny-bags, stack it, and then fumigate. The cost for this combined procedure would be 10.76 Yuan/ton.

(5) The system is equipped with a blower (flow rate of 350m^3/h) that provides more rapid and uniform distribution of the gas throughout the grain mass.
(6) The distribution duct system was attached by hoops to facilitate installation and removal of the system, for cleaning of the empty silo.
(7) Ease in ventilating the grain to remove the fumigant at the end of the exposure period. The grain may be consumed after seven days of ventilation with fresh air.

Tanggu Grain Storage

This storage facility is located in the Tanggu district of Tianjin, not far from the "New Port". It functions mainly for short term storage and contains stacking-yards, storehouses, traditional locally-built small silos, and silos made of brick and steel. The modern silos were built over the last 10 years. The traditional-type silos (90 ton capacity each) are all in poor condition. Grain is stored in these facilities for 6-9 months only. Temperatures at the center of the silos range from 2-27°C throughout the year, and grain m.c. ranges from 12-14%. As the upkeep and repair of these silos is expensive due to their poor quality, most have been replaced by modern-type silos.

In 1985, Tanggu Grain Storage facility constructed small steel silos (90 tons capacity per bin). These are used to store rice and wheat for 1-1.5 year periods. In these bins, temperature measurements revealed fluctuations from 0-32°C throughout the year, and in-bin m.c. ranged from 12-13%. Some large capacity steel silos have also been erected. In the small steel silos, heat transfer between the grain and the ambient air is a problem while in the large silos both heat insulation and gastightness problems have arisen. In 1988, aeration systems were installed in 20 of the steel silos for the purpose of grain cooling (Anon. 1992). Results of an aeration trial are given in Table 1. From the Table it may be seen that aeration with a blower (Model 4-72-11 No. 4) giving a total flow rate of 3,420-4,020 m^3/h, through the radially positioned on-floor distribution ducts used in this system, produced an average reduction in temperature of 11°C and unification of temperature throughout the bulk after a total of 32 hr aeration. Aeration costs to reduce the temperature of 1 ton of grain by 1°C were 0.038 Yuan, as compared with 28.00 Yuan for manual removal of the grain from storage for aeration purposes.

A large number of brick silos, mainly of 120-ton capacity, were built during 1988 and 1989. Grain m.c. recorded in the upper bin layers ranged from 12-15%, and grain temperatures throughout the year ranged from 0-30°C. This type of silo is considered very suitable for local conditions with good prospects for future development.

Table 1: Aeration trial in 80-ton steel silo containing wheat, 21-25 September 1988.

	low	high	average
Grain temperature before aeration	28	30	29
Grain temperature after aeration	17.5	18.5	18
Air temperature during aeration	14	22	18
Reduction in grain temperature			11

Total aeration duration: 32 hr
Aeration hours: 8 p.m. to 4 a.m. (total of 8 hr each night).
Number of nights: 4.

Gas-tightness tests and combined fumigation-aeration trials were carried out in 20 of these brick silos from June 1990 - August 1991. The silos are 14.27 m high with 7.45 m outer diameter and 6.6 m inner diameter. The silo base is fitted with a steel cone for unloading, and the roof of the silo is made of poured concrete. The roof of the silo is fitted with a manhole, aeration duct, and grain inlet chute. Both internal and external wall surfaces were painted with two coats of acrylic sealant. Grain is loaded to a height of 11 m, and total capacity is 240 tons per bin. A gas-tightness test showed that in the upper, middle and lower sections of the silo, pressure decay was 2,000 to 1,000 Pa within 45 sec. This was considered satisfactory for local needs.

Using the dual purpose fumigation-aeration systems for aeration of wheat, an average reduction in temperature of 10.1°C was achieved as shown in Table 2.

Table 2: Aeration trial in 240-ton brick silo containing wheat using dual purpose aeration-fumigation system, 9-13 January 1991.

	Temperature before aeration (°C)					Temperature after aeration (°C)				
Depth	East	West	South	North	Center	East	West	South	North	Center
1m	11.2	9.8	10.1	8.8	9.5	1.5	0.9	1.2	1.0	1.4
2m	10.0	8.8	8.9	8.8	8.1	0.2	0.2	0.3	0.1	1.1
4m	8.7	7.3	8.1	7.8	8.9	-0.2	1.3	1.2	1.6	1.8
6m	18.2	11.1	9.0	9.5	10.9	-0.9	1.1	1.3	0.9	1.2
8m	15.9	15.3	17.0	15.2	17.7	0	0.9	0.8	0.9	0.4
Average	11					0.87				

Total aeration duration : 48 hr
Centrifugal fan with a flow-rate of 600m^3/hr.
Number of nights: 4.
Air temperature during aeration : -7.0 to -1.9°C (average : -4.2°C)

RURAL STORAGE

In early December 1991, a survey was made of storage at 5 family farms located at Dong-Yuan village, in the Jin-hai county of Tianjin (Jinwei and Hong, 1991). The results of this survey are given in Table 3.

From the Table it can be seen that the farmers use several methods to store their grain, although they all seal the containers. Wheat m.c.s are at safe levels and the wheat is stored for future use. It may be possible to improve the storage methods by coating the brick tanks and iron drums with acrylic sealant, or by inserting oxygen scavenging materials into the containers so as to obtain oxygen deficient atmospheres for insect control. These options are under consideration by the Tianjin Bureau.

Table 3: Farmer grain storage in Dong-Yuan village.

Family	Storage method	Grain	quantity (kg)	Years of storage	Percent m.c.	Method of sealing
Wang Jikuan	brick tank	wheat	1,300	4	10.6	PVC sheet
Wang Jipin	brick tank	wheat	3,000	3	11.9	PVC sheet
Xui Zhepin	iron drum	wheat	3,000	4	12.3	cover tightly sealed
Zhang Jinzhong	water jar	wheat	4,000	1	10.2	powder of saltpetre
Zheng Shoxin	mud jar	wheat	1,900	4	12.5	mud

DISCUSSION

Urban storages: Contracts in international trade and regulatory requirements make it essential for routine fumigation of commercial goods in Tianjin. Storage facilities in Tianjin are being modernized; many new silos have been built and tested. Five different fumigation ducting systems have been introduced. With the combined fumigation-aeration system, insect control is achieved effectively due to improved gas-tightness of the structures. Following fumigation, grain is cooled by aeration thereby protecting the grain. This combined fumigation-aeration system has proved most suitable, and installation of this system is gradually increasing in scope.

The gas-tight storage and aeration systems have been developed for grain fumigation. However, they should also be developed for controlled atmosphere (CA) technology which is now under consideration. The concept of CA technology is in early stages of investigation in Tianjin and requires basic studies and the benefit of international exchange of information.

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