REQUIREMENTS FOR THE INTEGRATION OF LARGE-SCALE HERMETIC STORAGE FACILITIES WITH CONVENTIONAL SYSTEMS

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1. INTRODUCTION

Large-scale hermetic structures can be satisfactorily used for the long-term preservation of food grain, and may be be built partially or totally underground to simplify construction and to reduce costs. While in such structures it is convenient to handle grain in bulk, in the tropical countries where the technology could be employed, grain is generally held in bags. There is need therefore to suitably integrate handling systems to avoid congestion and delays in transport of the grain.

Quality requirements for grain intended for long-term air-tight storage are more stringent than for short term, conventionally stored produce and must be taken into consideration when selecting appropriate sites for hermetic bins. Locating in areas of surplus production will ensure that fresh, good quality grain will be received with the minimum of delay.

When planning for a large scale hermetic food reserve, it is important to have clear policy guidelines for smooth operation. A clear decision must be made on the role of the food reserve and priorities on maintaining its status in relation to food stocks in conventional stores.

Experience has shown that a large scale grain famine reserve must not be isolated from the general handling and marketing system. It must as far as possible be an economic enterprise and be able to receive produce directly from farms, as well as, in the absence of famine,to dispose grain stored for long periods directly into the normal marketing outlets.

2. AIR-TIGHT BULK STORAGE IN THE TROPICS

Grain stored in bulk in an air-tight structure requires to be handled in a different way from conventional silos.

2.1 Moisture migration and condensation

By definition, an air-tight structure does not permit ventilation, and grain in such containers should be thoroughly dry below 12.5%. To prevent moisture migration, the grain should be cooled to ambient temperatures before loading. Under tropical conditions, there exist fairly wide differences between day and night temperatures. The effects of these temperature variations are greater on semi-underground structures and less on fully underground silos. Moisture condenses on the roof and drops on the surface layer of the grain enhancing fungal growth. These problems cannot be entirely solved economically but with adequate precautions can be made negligible.

2.2 High temperatures and grain heating

Day temperatures in the tropics are generally above 20^{o}C and are often in the region of 25 - 30^{o}C. Although grain itself is a fairly poor conductor of heat, the inter-granular atmosphere will respond more rapidly to high external temperatures.

External temperatures, notwithstanding, severe grain heating can occur when the grain bulk is not free from dust and thrash that accumulates during mechanical harvesting and handling. In temperate countries, low external temperatures have a delaying effect on internal heating when grain is contaminated with extraneous matter. In the tropics, grain intended for long term air-tight storage must be thoroughly cleaned to avoid serious internal heating of the grain bulk.

2.3 Grain Handling

There is no difference in principle in loading and unloading partially and completely underground hermetic silos. These operations are however not as conveniently undertaken as in fully above ground silos. Semi-underground silos are easier to unload than fully underground structures.

The type of conveying system used will have a direct effect on the capital costs. Mechanised belt conveying systems (overhead or underground) are expensive and may not be conveniently designed for use with air-tight silos.

Conveying equipment should be simple and require little maintenance and should handle the grain with the minimum amount of damage. Handling equipment should have sufficient capacity to meet annual requirements of loading and unloading a pre-determined proportion of the storage capacity. In periods of shortage, these should be anticipated a few weeks in advance since the normal site capacity will be unable to handle emergency requirements.

It is obviously uneconomic to have a large quantity of surplus equipment on stand-by for periods of crisis. Suitable integration of famine storage with conventional systems will ensure that surplus handling capacity on site will be profitably used when there is sufficient grain in the conventional system.

2.4 Monitoring and quality control

Provision has to be made on site for recording the produce by weight over a weigh-bridge and maintaining an accurate check of site records by weighing grain into and out of the hermetic silos. This will ensure that an accurate assessment is made of the various losses and an economic evaluation of possible remedies can be made.

Grain quality can be monitored rapidly and on a routine basis by fitting each bin for remote sensing of temperature, moisture and oxygen. Provision should also be made for taking grain samples. Constant monitoring of the produce will enable a check to be maintained on the quality as well as take preventative measures to avoid serious mishaps.

3. OPERATIONAL PROCEDURES AT THE "CYPRUS" BINS IN KENYA

3.1 Handling on arrival

Farm produced grain normally arrives in bags and is thoroughly inspected before acceptance. The accepted bags and produce are passed over a weigh-bridge and emptied into the intake pit of the cleaning and drying plant. Since the grain is expected to remain in the bin for at least 3 years, only fresh good quality produce is accepted.

3.2 Cleaning and drying

Dust and dirt are removed from the grain before it passes into the drier where the moisture content is brought down to 12.5%. The dry grain is fed into a temporary "dry bin" (part of drying plant itself) and later discharged into a bulk carrier for delivery (via the weigh-bridge) to the site of the hermetic bin being filled.

3.3 Filling

The bulk carrier feeds the grain into the intake hopper of the loader and the grain is elevated by a chain and flight conveyor with an average capacity of 65 tonnes per hour. A bin can be filled within 3-4 days but generally takes longer because of delays in supply and handling. However, no filling is expected to take longer than 3 weeks. At the later stages of filling a spinner is used to obtain a complete trimming of the bin. (This is necessary because the top of the "Cyprus" bin is nearly horizontal, less than the angle of repose of the grain). The bin is then sealed for at least 6 months to attain hermetic conditions and control infestation.

3.4 Emptying

A bin to be emptied is first properly ventilated for at least 2 hours by opening the top and side hatches. Wet and rotten grain below the top hatch, at the ring beam, and at the bottom is removed separately, weighed and destroyed. The damp and mouldy grain next to the rotten grain is also removed separately, dried and aerated in the cleaning plant, bagged and retained for inspection if suitable for animal feed.

The unloader is a separate machine from the loader. Unloading is done by lowering the (Redler) Boom Conveyor through the side hatch. The grain is discharged directly into a bulk carrier and conveyed via the weigh-bridge to the cleaning and bagging plant.

4. OPERATIONAL DIFFICULTIES AND POSSIBLE IMPROVEMENTS

In addition to the structural problems which have been satisfactorily solved, the normal operation of the hermetic storage sites has been subject to a set of handling problems arising from inadequate pre-planning and design of sites for suitable integration with conventional handling systems. As a result the facilities on site were not sufficiently equipped to receive, clean and dry grain rapidly during the 4-8 week peak delivery period after the harvest.

This resulted in considerable delays especially in the early filling operations in 1972 (Figure 1). The time lapse between beginning and concluding a filling is indicated by the open block in front of the black strip which is the length of time the produce remained in the bin. The open block at the end of the black strip is the period during which emptying was initiated and completed for a particular bin. An arrowhead at the end of an emptying period indicates that the contents were transferred to another bin for a further period of storage. Transfers were made when heating problems were especially severe.

The filling periods were considerably reduced during the second time the bins were filled in 1975. This was because more efficient equipment was installed on site and handling rates were improved (Table 1). The cleaning rate is dependant on the rate at which the produce passes through the drying plant. Drying capacity will have to be increased by at least 4 times.

5. OPERATIONAL COSTS

The bins require constant maintenance for sealing cracks and for preservation of the bituminous membrane on the dome. There are several site installations including the cleaning and drying plant, laboratories,garage and general utility buildings. The special loading and unloading equipment, bulk-carriers, tractors and other vehicles also need maintenance. The roads and ground surface near the bins must be constantly repaired to avoid damage to the underground structure.

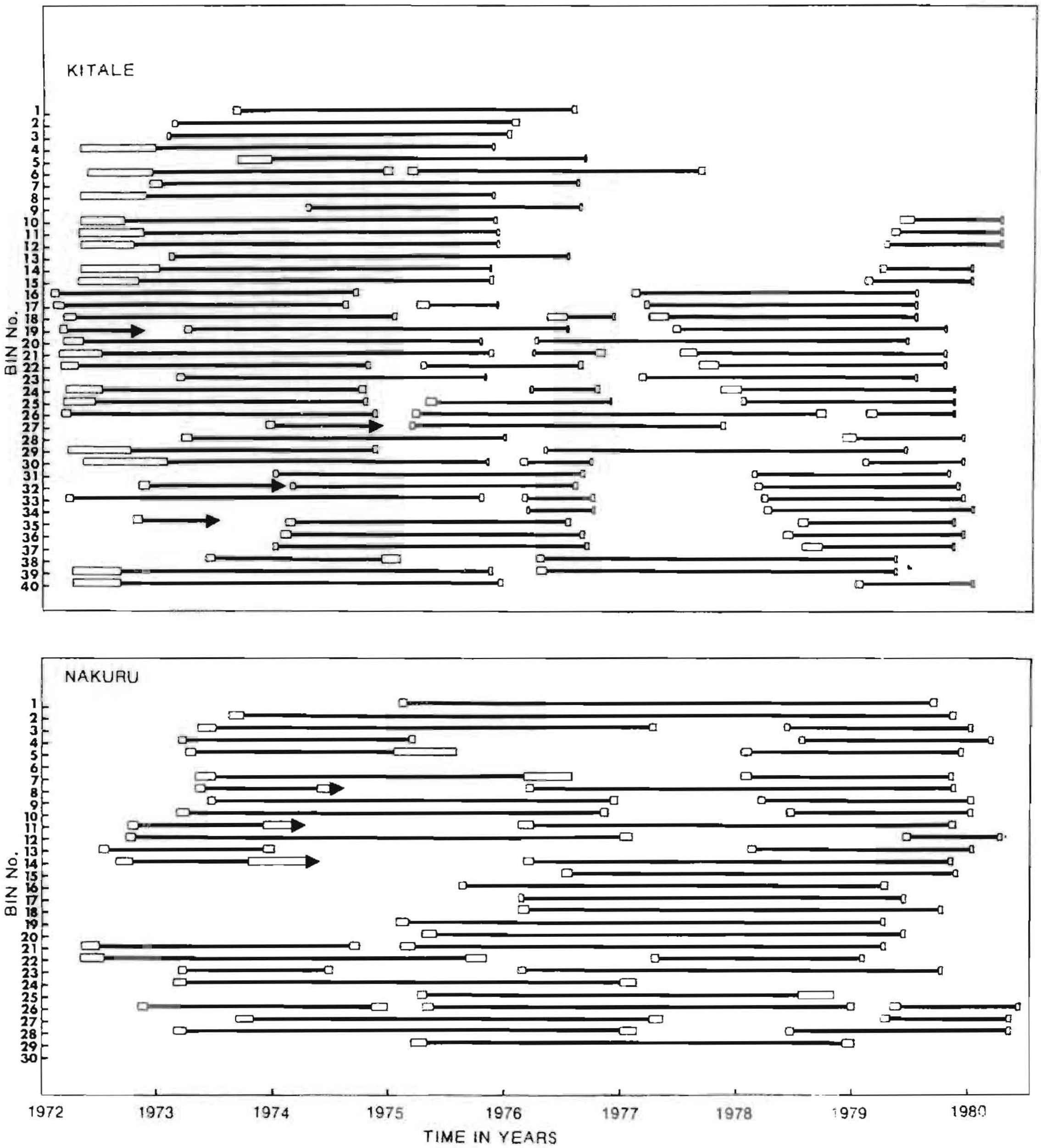

Fig. 1. Filling and emptying operations over the years 1972-1980 at the Kitale and Nakuru sites.

NOTE: The figure illustrates records for maize storage only. However, at Nakuru, wheat was stored on several occasions and this partly accounts for the long periods shown "empty" for certain bins. Bins 6, and 30 remained unused at Nakuru due to defects in construction.

TABLE 1

Handling capacity at the Kitale and Nakuru sites and future requirement.

Operation	Handling capacity (tons per hour) Initial	Current	Required
1. Cleaning	15-20	15-20	30-40
2. Drying (to 12.5%)			
from 13.5%	8-10	8-10	30-40
from 14.5%	4-5	4-5	15-20
from 15.5%	2-2.5	2-2.5	10-15
3. Loading (filling)	5-15	60-70	60-70
4. Unloading (emptying)	5-15	40-50	80-100
5. Bagging	20-24	20-24	80-100

During operation there are various costs including pest control, fuel and labour hire charges. There is a minimum technical and maintenance force under permanent employment.

These costs have generally averaged in the region of 60,000 U.S. dollars per annum and gives an average cost of 0.6 U.S. dollars per ton per year of storage. These costs compare very favourably with conventional storage where annual pest control costs alone are in excess of 0.3 U.S. dollars per ton per year (pest control in the hermetic bins costs less than 0.00133 U.S. dollars per ton per year).

6. INTEGRATION OF HERMETIC STORAGE FACILITIES WITH CONVENTIONAL SYSTEMS

In addition to the uncertainties of rainfall and other climatic factors, many countries in the tropics often face difficulties in obtaining essential agricultural inputs like fuel and fertilisers. Establishing sufficient food reserves for use in periods of shortage is a wise course of action. These reserves should be essentially long term i.e. of 3-5 years duration.

Experience in Kenya has shown that the handling of such reserves requires careful planning and should as far as possible fit in with the normal handling procedures for conventionally stored produce.

6.1 Siting of hermetic storage facilities

Since it is essential that fresh, good quality grain be used, the hermetic structures should be sited in an area of surplus production. Farmers will be encouraged to deliver directly and avoid delays, normally caused by the use of intermediaries, and there will be lower transport costs. In constructing hermetic structures partly or fully underground, account should be taken of the physical structure of the soil and depth of the water table.

6.2 Cleaning, drying and handling equipment

Grain intended for long term storage must be dry and free from dust and thrash. In planning for capacities of equipment needed for such work consideration must be given to long term projections and the possibilities of extending the use of the facilities. For example, drying facilities originally built for the "Cyprus" bins were later found to be inadequate to cope with a more general demand from thefarming community for drying facilities to enable early delivery for conventional storage. Additional facilities were constructed in 1975 several miles away from the Kitale site and it was not possible to satisfactorily integrate these facilities for use by the"Cyprus"bins site during peak delivery periods. Additional drying facilities for conventional storage have since been constructed at Kitale and will be available for drying grain for the"Cyprus"bins in 1981.

6.3 Stock control

When hermetic storage is planned for 3 to 4 years, there should be a proper schedule to turn-over 1/3rd or 1/4th of the stock every 3 or 4 years. This will reduce the quantities being handled each year and also ensure that the work load and operations on site are spread out through the year. Every year, grain that has been stored for 3 or 4 years may be released into the conventional marketing system for milling. In this way, some of the grain which has acquired a certain amount of mustiness from long term storage can be satisfactorily blended with fresh grain in the milling process.

Each year, emptying operations should begin several months in advance of the next harvest and the empty structures suitably repaired and serviced for immediate use. Many delays in receiving and filling bins occur because of the insufficient time given for undertaking maintenance work.

6.4 Interacting systems

This paper gives attention to the aspects that need to be taken into consideration when a country is planning to improve its food security by preserving a fraction of its national requirements on a long term basis. Although hermetic storage is a low-cost and technologically effective system, there are other alternative technologies.

Whichever technology is adopted in a given country, the concept of a long term famine reserve will remain. Whatever conventional handling systems are already operating, there will be a need to provide for an adequate interaction with the famine reserve system.

The main areas of interaction are illustrated in Figure 2. Grain is often handled in bags in tropical countries because produce can be conveniently delivered in this way by large numbers of small scale producers, or merchants and other intermediaries. Conventional systems are therefore geared to handling produce in bags. Since long term famine reserves are more conveniently handled in bulk, some additional handling will be required.

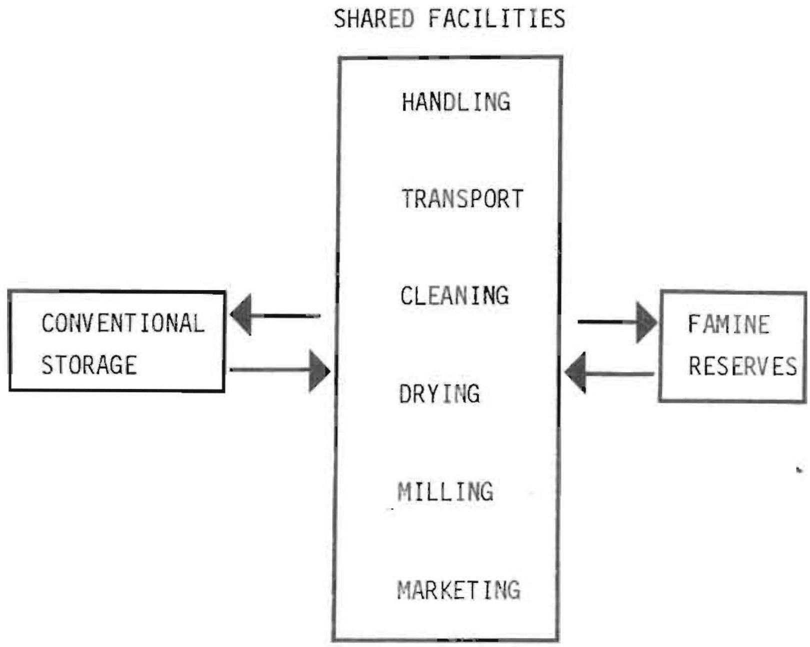

Figure 2. Common facilities for conventional storage and hermetic famine reserves.

For rapid acceptance and, more important, for rapid despatch in times of crisis, adequate provisions for transport must be made. Rail transport can often be provided for at relatively low cost and wagons for handling in bag or bulk can be made available for transport of grain as well as other commodities. Road transport is more convenient in bags but in periods of crisis rapid turn-round of trucks carrying bags may not be easily achieved.

Cleaning and drying facilities are essential for long term food storage and are increasingly in demand for conventional bag storage. Such facilities may therefore be conveniently shared.

After the grain has completed a specified period of storage there is need to release it to the consumer. The grain has to be milled and then marketed. When grain has been stored for a long period of time it will acquire a certain amount of mustiness and other off-odours. Under tropical conditions these odours are generally unavoidable but when mixed with fresh produce during milling are completely undetectable. Adequate liaison should therefore be maintained with milling and marketing organisations to obtain consumer acceptance of produce after long term storage.

7. PLANNING AND ECONOMIC ASPECTS

Total construction costs for the "Cyprus" bins in Kenya were given as 14 U.S. dollars per ton capacity in 1966-67. These were found to be extremely favourable in comparison with costs for conventional bag stores at that time. In 1975 the construction costs for modern conventional bag stores for the Maize Board were put as 22 U.S. dollars per ton capacity. With current world inflationary trends these will have risen considerably and hermetic storage with its low constructional costs should be extremely competitive.

Hermetic storage is not an alternative to more conventional forms of bag and bulk storage. It is a long term option and has a role in preserving food stocks for security in the event of famine. This aspect must be taken into account besides other purely economic costs when considering future investments.

A famine reserve must not be held in isolation. It must be operated as an economic enterprise during normal years and must be integrated with the existing grain industry. Thus, it may be located in a grain surplus area and operated on a site adjacent to conventional stores and a milling complex. This will enable sufficient "over-capacity" to be economically utilised during non-famine periods and to ensure that sufficient capacity exists for handling during periods of crisis.

Plans for long term famine reserves should therefore take into consideration long range construction programmes for the grain industry. The economies of scale can be successfully employed, especially in the use of common facilities, and overall costs for both, long term and conventional storage, considerably reduced.