# REPORT ON THE F.A.O. TECHNICAL TRAINING PROGRAMME ON THE KONGSKILDE GRAIN DRYING AND STORAGE SYSTEM



(SEPTEMBER 23RD, - OCTOBER 5TH, 1985)

by

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# REPORT ON THE FAO TECHNICAL TRAINING PROGRAMME ON THE KONGSKILDE GRAIN DRYING AND STORAGE SYSTEM, KUMASI (SEPTEMBER 23RD - OCTOBER 5TH 1985)

## 1. INTRODUCTION

### 1.1 Background and Justification:-

This was a two-week residential course organised by U.N. Food and Agriculture Organisation especially for the Pest Control Staff of the Ghana Food Distribution Corporation (GFDC), on the use of the Kongskilde grain drying and storage system.

The GFDC, is the Government agency under the Ministry of Agriculture responsible for purchasing, storage and distribution of locally produced foodstuffs and cereal food grains in particular, in order to ascertain stability of food supply and producer/consumer prices in the country. For this purpose, GFDC purchases about 10% of production. At present, it is also involved in the handling and distribution of imported food. In Ghana available storage capacity at national and regional levels can cater for 20-25% of the total grain produced and the remaining 75-80% is either sold cheaply at harvest or poorly stored by rural farmers at heavy losses. In the past, proper handling and storage of grain was ignored with the erroneus idea that grain once produced would automatically find reasonable market, no matter how it was presented. The result has been disastrous for our agricultural programme and food preservation generally. The importance and relevance of the course to the country's agricultural pursuit in grain handling and storage for food security cannot therefore be over-emphasised.

The existing GFDC facilities are of various types, including unfinished concrete silos system (1960s) different types of metal and Butler silos (1979).

However, the acquisition of these have been on ad-hoc basis rather than on systematic planning. The Kongskilde units were therefore sold to the GFDC with favourable terms. But due to the shortage of foreign exchange, installation and training of personnel to man the systems was delayed. The suppliers, Kongskilde Makinfabrik A/S of Denmark, have been given a recent extra quotation for training which formed part of the FAO assistance.

### 1.2 Participation

Thirty-four (34) participants attended, made up of 18 pest Control staff of the GFDC, and 2 staff members of each of the national institutions concerned with agricultural engineering and other aspects of grain drying and storage, ie. the agricultural engineering departments of the Universities at Legon, Cape Coast and Kumasi, the Food Research Institute, Grains Warehousing Company and the Kram Consultants. The purpose of involving these institutions was to substantiate the joint institutional approach in Ghana's grain drying and storage systems and to establish a rational training group. Seven foreign experts also attended. These were Mr. Jose Arboleda, the FAO Project Officer at the International Rice Research Institute in the Philipines; Mr. Yoshiki Konuma, the FAO Programme Officer for Ghana and the FAO Resident Representative in Ghana; Mr. Kukulay. The rest were Mr. Bennet Anker Olsen, Mr. Alan White and Mr. Neils Anderson, all from Kongskilde Makinfabrik A/S Denmark.

### 1.3 Course Objectives

Generally the objects of the course was to assist the GFDC in initiating ie. design, organise and conduct in collaboration with the supplying company a programme of operational and maintenance training for Kongskilde drying/storage units. Specifically, the course was to enable participants to learn:-

a. the biological and physical aspects of grain storage

b. the engineering principles of grain drying and storage with special reference to the climates of Ghana

c. the operation and maintenance of the Kongskilde drying and storage system with special reference to the local engineering capacity.

## 2. METHODOLOGY

The teaching, training method, and techniques used were as follows:-

a. Lectures and talks by the FAO and Kongskilde experts
b. Tutorials and special assistance by the experts to individual participants
c. Two field trips to Abofour, (35 miles from Kumasi which is a GFDC maize purchasing and drying centre) and a farmers' rally was held to expose participants to the practical aspects, rational and importance of the course.
d. Films and slides were shown to make points in lectures more understandable.
e. Group discussions both formal and informal under the guidance of the experts to mount, assess, and evaluate engineering systems in particular.

f. A Kongskilde file on the course work, questions and materials for further reading was given to each participant for future reference, and further reading.

3. FIELDS COVERED

The course was designed into TEN main headings but integrated as follows:-

3.1 An Introduction to the Kongskilde Organisation

Kongskilde is a multinational organisation established in 1950 with its headquaters in Denmark. Subsidiaries of the company are in W. Germany, Holland, Canada, U.K., France, U.S.A., Austria, Italy, Finland, Brazil and Australia.

The special structure of Kongskilde's Internatioanl Organisation permits the company to study the agricultural and market conditions in each country and to adapt produce to accommodate the widely differing demands made upon plant and machinery. The company has wide international experience in designing and building drying and storage plants and complete turnkey seed-processing systems for many different crops.

Kongskilde has two primary lines of production:-

(a) implements for soil preparation, and

(b) equipment for handling and conveying grain.

3.1.2 The Kongskilde Grain Drying and Storage Systems

The objectives in grain storage are to maintain all the quality and quantity produced at harvest so as to maintain constant supply during the lean season, to service a trading system and to retain seed for planting in the next season. Kongskilde recognises, the manipulation of two very important physical parameters of grain at harvest in order to achieve these objectives. These are moisture content and temperature.

A freshly harvested grain breathes and is full of life. Dry, cold conditions are necessary to make it hibernate. These are necessary because the living seed will generate its own heat and moisture, thus destroying the elements essential for good quality bread and feeding compounds. Failure to control heat and moisture could seriously affect the germination quality. Heat will accumulate in heaped, damp grain in which air is stagnant. The heat accelerates the breathing of the grain. In the resultant warm damp conditions, germs and fungi flourish, making the grain mouldy and musty so that it cannot be used as seed grain, food or flour and becomes poisonous as feeding grain. Grain can be stored in perfect condition when moisture content and temperature are kept low. This is exactly what the Kongskilde system achieves by using ventilation to dry the grain and control its temperature.

## 3.2 GRAIN BIOLOGY

To understand the idea behind handling and processing of grain it is necessary to learn the nature of the kernel and its environment.

### 3.2.2 Grain taxonomy and Grain Parts

All cereal grains, maize rice, sorghum, wheat, millet etc. belong to the same grain family called Graminae. Even though they do not look alike, they share three basic parts: the seed coat, the endosperm and embryo (germ).

The seed coat surrounds the embryo and the endosperm. It protects the grain from attack by certain insects if it is dry and uncracked. It cannot keep out moulds and some insects. Those insects which attack the embryo are most dangerous because the seed coat of the embryo is weak.

The endosperm takes up the largest part of the seed. It is 80% of the kernel volume in most grains. It is the seed's food storage place. It is mostly starch and protein. Also, it provides food for the developing seed when planted and food for the seed in storage.

The embryo, on the other hand, is the part which can develop into a new plant. It contains most of the protein, fat, and vitamins of the grain. It is easily attacked by some insects and by moulds. Seed grain which is attacked will not grow into strong plants or will not grow at all. Food grains without embryos do not provide as much nutrition as grain with embryos.

The relative proportions of grain constituents ie. carbohydrates, proteins, vitamins, minerals, fats, fibre and water vary with the type of produce and also the treatment to which the produce has been subjected during handling and processing.

### 3.2.2 Grain Respiration

This is a process that measures the life activity of the kernel. Each kernel gets oxygen from the air and burns food from its endosperm. The process gives off heat, water and carbon dioxide thus:-

$$\text{Glucose} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water} + \text{Heat}$$

$$C_6H_{10}O_5 + 6O \rightarrow 6CO_2 + 5H_2O + \text{Heat}$$

By calculation, 1.00 gm of glucose requires 1.20 gm of oxygen to produce 1.60 gm carbon dioxide, 0.60 gm of water and 3.76 kacal of heat. Or if we have 1 ton of grain, respiration removes 1% dry matter and 6kg of water will be produced increasing the moisture content by 0.06%. Also 37500 kcal of heat will be produced increasing temperature by 65°C.

Grain temperature measurements are therefore necessary for grain storage because it gives an indication of spoilage due to fungi, bacteria and insect activity. Ventilating the mass by a fan, a process called aeration can be used to reduce grain temperature.

Respiration is a self-accelerating process. The moisture produced can increase the moisture content of the grain which in turn can cause an increase in respiration rate, also the heat produced can raise the grain temperature in turn increasing respiration rate.

3.2.3 Grain Moisture

This is in 2 forms: water of composition and absorbed water. The amount of 'free water' present is critical to the rate of deterioration of produce.

There is an exchange of moisture with the surrounding atmosphere, to maintain a balance which always exists, between the moisture in the produce and that in the atmosphere.

Temperature and variable vapour pressure cause moisture movement. Moisture may be transported by warm air which rises and, aided by convection current, carries moisture to areas of lower temperature. Surfaces. Movement of moisture out of individual grains occurs due to higher vapour pressures in the grain than exists in the surrounding air.

3.2.4 Conductivity

Food grains have relatively low thermal conductivity. As a result of this, there is accumulation of the heat produced. It was also discussed that, outside temperature fluctuations do not readily penetrate large quantities of stored grain or grain mass.

3.2.5 Flow and Pressure

Participants were familiarised with the characteristic flow property which is unlike that of liquids. Each type of produce has a natural angle of repose of about 30% but this varies according to the size, shape, moisture content and cleanliness of the grain.

Grains stored in a container exert both vertical and lateral pressure on the sides of the container unequally unlike liquids. This pressure varies with the moisture content of the grain because of changes in the coefficient of friction, which is greater at lower moisture contents.

3.2.6 Changes during Storage

These include the biochemical, functional and nutritive changes. Some of the changes are indices of deterioration. Carbohydrate and protein changes are not very significant in stored grain but with lipids, deteriorative changes may either be oxidative, resulting in typical rancid flavours and odours, or hydrolytic, resulting the production of free fatty acid. For this reason, free fatty acid content of grain is a sensitive index of incipient grain deterioration. Fats are broken down by lipases into free fatty and glycerol during storage, particularly when the temperature and moisture content are high and favourable to general deterioration. This type of change is greatly accelerated by mould growth because of high lipolytic activity of the moulds.

3.3 GRAIN DRYING

This aspect of the course was treated in order to explain to participants how removal of moisture by dr ing can make grain effectively stored up to 10 years, or more.

The moisture content (mc) of grain is the key to safe storage. Typical harvesting me and me considered for safe storage are shown in the Table below:

Table I

Moisture content during harvest and for storage per cent wet basis

| Cereal | Maximum during Harvest | Optimum at harvest for Mimimum loss | Usual when Harvested | Required for safe Storage | |
|---|---|---|---|---|---|
| | | | | for 1 yrs. | for 5 yrs. |
| Maize | 35 | 28-32 | 14-30 | 13 | 10-11 |
| Rice | 30 | 25-27 | 16-25 | 12-14 | 10-12 |
| Oats | 32 | 15-20 | 10 18 | 14 | 11 |
| Barley | 30 | 18-20 | 10-18 | 13 | 11 |
| Sorghum | 35 | 30-35 | 10-20 | 12-13 | 10-11 |
| Wheat | 38 | 18-20 | 9-17 | 13-14 | 11-12 |
| Millet | 30 | 20-25 | 16-20 | 16 | 14-15 |

Source:- C.W. Hall (1957), Martz (1969)
D.C. Hall (1970), Sinba (1973)

To give a safe storage, it is understood from above that the grain must dry enough to keep the life activity of the grain, insects, and fungi on a very low level. Kongskilde achieves this by using artificial dryers because natural drying is not possible in areas of high rainfall and high reletive humidity especially in the maize growing regions of Ghana.

3.3.1 Moisture content/Relative Humidity Relationship

The drying mechanism isbased on the fact that all granular materials exposed to air will after sometime reach moisture content in balance with the moisture content in the air known as the equilibrium moisture content. To understand the capability of air taking up moisture, it is necessary to understand the term 'relative humidy' normally written as R.H. often expressed in percentage.

The R.H. of air is expressing the actual content of water in one cubic metre (cbm) of air at a specific temperature as a fraction of the maximum content of water in one cbm of air at the saturation point at the same temperature.

Example : - if 1 cbm of air at 20°C contains 5.5 grams $H_2O$ and the same 1 cbm of air at 20°C at the saturation points, contains 17.5 grams $H_2O$

∴ The R.H. is:-

$$\frac{5.5 \text{ grams}}{17.5 \text{ grams}} \times 100\% = 30\%$$

This means that one cubic metre air with a RH of 30% at 20°C has a capacity to take up (17.5-5.5) = 12 grams of $H_2O$, before the saturation point is reached.

A fact which influences the m.c./R.H. relation is temperature, an increase in temperature lowering the R.H. and vice versa. Therefore in the farming humid tropics of Ghana, typical day R.H. is 55-85% and night R.H. is 75%-95%. At above 70% R.H. fungi, moulds, mites and insects develop rapidly since they utilize, water in the grain for metabolic activities. This leads to spoilage of the grain. For safe storage of produce, it should be dried so that its moisture content, is in equilibrium with not more than that of 70% R.H.

Table 2

Moisture contents in equilibrium with air of various humidities of room temperature approx. 77°F. 25°C

| Cereal | Moisture Content | | | | Wet Basis | | Authority |
|---|---|---|---|---|---|---|---|
| | 15% R.H. | 30% R.H. | 45% R.H | 60% RH | 75% R.H | 90% R.H | |
| White shelled Maize | 6.6 | 8.5 | 10.4 | 12.9 | 14.7 | 18.9 | C and F (a) |
| Yellow shelled maize | 6.4 | 8.4 | 10.5 | 12.9 | 14.8 | 19.1 | C and F (a) |
| Shelled pop corn | 6.8 | 8.5 | 9.8 | 12.1 | 13.6 | 18.4 | C and F (a) |
| Milled Rice | 6.8 | 9.0 | 10.7 | 12.6 | 14.4 | 18.1 | C and F (a) |
| Sorghum | 6.5 | 8.6 | 10.5 | 12.0 | 15.3 | 18.8 | C and F (a) |
| Soybeans | - | 6.2 | 7.4 | 9.7 | 13.2 | - | C,R and F(b) |
| White wheat | 6.8 | 8.6 | 9.9 | 11.8 | 15.0 | 19.7 | R and G (c) |

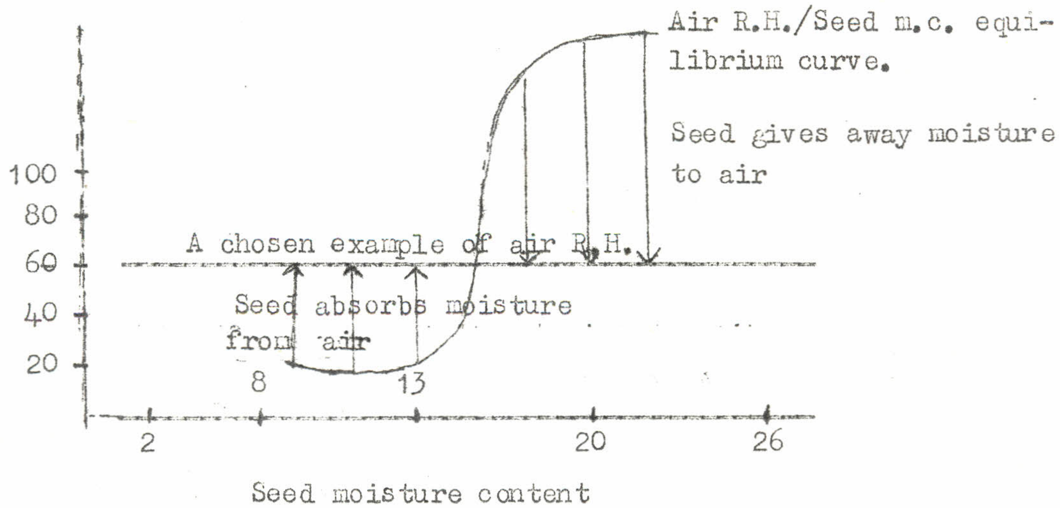
Source: (a) Coleman and Fellows (1925) : Moisture, content determined by water-oven method.

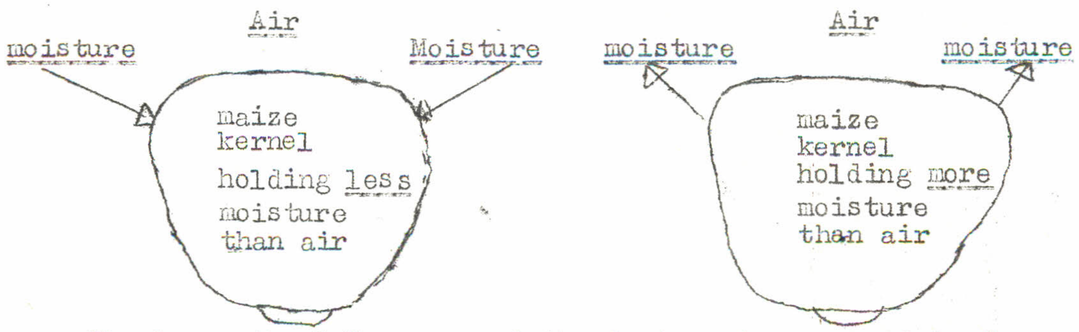
(b) Coleman, Rothgeb, and Fellows (1928) : Moisture determined by official air-oven method.

(c) Ramstad and Geddes (1942) : Moisture determined by vacuum-oven method.

### 3.3.2. The drying process

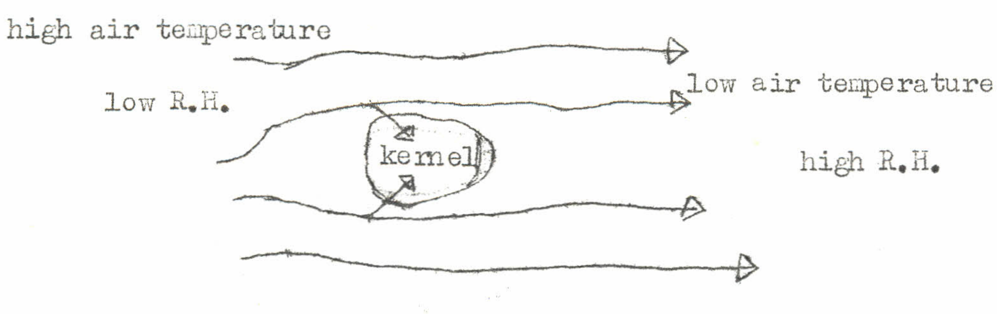
To have a drying effect lof the air it is necessary to have R.H. value somewhat lower than the figufes in Table 2.




The lower the R.H. value of the drying air compared to the equilibrium R.H. wanted, the more water can be taken up by the air and the faster the drying will go.

When air is heated up, the R.H. will do down - it means the capacity to take up water is increased. This is the basis on which all air drying is based.



When heated dry air passes around a kernel, some heat will be absorbed by the kernel giving energy to evaporate water from the surface. The drying air after the passage will have a slightly lower temperature and a higher m.c. The kernel would have lost water and is heated up a bit. It is only very close to the end of the drying sequence that the kernel obtains a temperature very close to the drying air temperature because the evaporation of water consumes most of the heat. The internal transportation of water inside a kernel should go almost as fast as the evaporation from the surface of the kernel, otherwise there will be a dry shell around the inner part. Such a shell can slow down the drying and the outer layers can shrink so much that cracks will develop over the surface. Such cracks may be microscopic but can be starters of complete breaks at a later stage, eg. conveying or milling.

### 3.3.3 The Kongskilde Batch Drying

The Konskilde Drying system consists of a Heater, a Blower and the Drier or Grain Drying Unit. In the Drier, high volume airflow is raised to give a maximum temperature of 40°C (105°F) for maize 65°C (150°F). At this temperature grain quickly gives off moisture which the airflow carries away. The speed of drying (2 to 20 hours) prevents any decomposition due to high temperature. Grain is then cooled for 2-4 hours in the same Unit Drier. The Unit Drier is recommended for installations which consist of silos over the 67 tonnes size and in parts of the country where incoming grain is often above 20% moisture content.

The heated airstream passes up a perforated vent pipe and flows out evenly through the grain. An Additional feature is the double-blow effect of two parts of drying air - one moving out radially, the other from the base - flowing through to the silo walls. This is of additional benefit for every high m.c. grain and when the Unit Drier is only partly full. Total use is made of air-flow and heat. Air passes out of the silo saturated with moisture from the grain unti the grain reaches a low enough moisture content to be storable.

The fact that most insects, eggs and larvae are killed at temperatures, above 40°C emphasises the importance of letting all grain pass through a drier, when entering an installation.

## 3.4 KONGSKILDE GRAIN STORAGE

Having familiarised themselves with the Kongskilde grain drying system, participants were taught the Kongskilde grain storage. Better storage is necessary as :-

- approximately 30% of grain in storage all over the world is lost because of insects, rodents and moulds.

- Improving grain storage would mean less hunger, improved nutrition for the individual and a higher standard of living, and a sounder economy for the nation.

- quality grain for international trade is of increasing importance.
- improper storage of grain leads to weight loss, monetary loss, seed loss, food loss.

### 3.4.1 The Kongskilde Silo

Kongskilde makes use of ventilated silos (for drying and storage) which control grain temperature and mc to ensure that the qualities of the grain are preserved. Because temperature is kept low from the start, m.c. cannot increase grain's activity. Therefore drying is accomplished in a matter of one or two weeks by the natural temperature rise of air supplied from a high pressure blower. The blower compresses the indrawn air and raises its ambient temperature by 4.5°C (8°F). The drying air stream is blown into the perforated ventilation pipe and passes out in an even pattern through the grain. Grain is even dried in rainy weather.

To cope with incoming grain, a combination of the storage silo and Unit Drier is ideal. The Silo takes newly harvested grain and pre-dries it while the Unit Drier is filled, and dries, cools and empties its contents. By giving the Unit Drier a complete, pre-dried fill each time and maintaining it in a constant fill-dry-cool-empty cycle, its hourly output is kept at maximum. The combination makes grain handling simple even in critical harvest conditions.

### 3.4.2. Moisture migration and advantages of the Kongskilde storage silo

Moisture movement is normal in any storage where variations in temperature exist. During cold periods, grains located near the exposed walls and upper surfaces cools more rapidly than that in the surface of the bin. This temperature difference causes slow convection currents in the bin with the warm air, which rises through the centre of the grain mass, carrying moisture from the warmer grain to the colder surface again with cold grain, temperature and warm ambient temperatures, the air flow patterns are reversed. Moisture accummulation may be serious enough to cause moulding and crusting on the grain surface and spoilage in other parts of the bin.

Day and night temperature variations have a similar effect. This day-night variation can cause condensation to form on bin roof and walls causing 'rain' to fall on the grain surface or grain to beeaome 'glued' to the wall, caking, crusting and mould is the usual result. Often the spoilage is blamed on silo leakage around walls or roofs. The realistic cure is to provide overspace ventilation in the roof and to keep the grain on the cool side. In stored grain having uniform temperatures, moisture migration does not take place. Aeration is a means of equalizing temperatures in stored grain.

Because the Kongskilde system is put up inside a building the change in temperatures are far loss than in outside silos and the change in temperature is much slower. This gives far less moisture migration in the grain mass inside the Kongskilde storage silo. The wooden wall also acts of a kind of insulator to the slow changes in temperature. Because all Kongskilde silos have a very powerful ventilation system, temperatures inside the silo can quickly be equalized and eventually released moisture carried away by the ventilation air. The wooden/aluminium construction covered aluminium strips allow free passage to the drying airstream. The strips are self-cleaning non-corrosive and unaffected by crop moisture. Grain level can be checked through special aluminium strips between each silo wall section. The Kongskilde storage silo also provide easy inspection in many points, and no strong foundation required.

## 3.5 KONGSKILDE PRE-CLEANING AND CONVEYING

Participants were shown how a lot of trash, sand and dust is mixed with the grain coming to a drying and storage installation are removed. This is called pre-cleaning and Kongskilde uses two types:- the aspirators and the air screen cleaners.

Conveying systems used by Kongskilde include the Pressure blowers, Suction conveyors , Suction blowers, Single augars, coupled augers around corners, Belt conveyors and the Elevator. All these systems use particular flow directions, advantages and fields of use, maximum throughput, minimum and maximum conveying lengths and motive power electric motors that must be used.

## 3.6 TESTING AND SAMPLING

These are the KM Moisture meter, Thermo-meter with grain sampler and the Thermo-control.

The KM-Tester assists in determining the right time to harvest. With a KM tester on the combine, grain damage is of minimum since it measures moisture content. Also drying time can be pre-determined easily and harvest efforts planned accordingly. One can control the progress of drying and know exactly when to stop - not too soon and not too late, thereby attaining the best possible drying economy.

It is especially during the first period immediately after the grain has been stored that the Kongskilde thermometer is an essential help to guide drying and safe storage of the grain. The grain samples is fitted to the same handle as is the thermometer and is used for extracting samples from the silos for determination of the quality of moisture content of the grain. Sampling and temperature control readings can be taken from any part of the silo by using extension rods.

Since the Abofour drying plant is not large enough, the Thermo-control was not installed. But its operation is simply for temperature measurements of grain and seed crops from a central point.

3.7 MOUNTING AND ERECTION OF KONGSKILDE SYSTEM

Participants compared Kongskilde silos in particular to other in mounting and erection. It was observed that fully illustrated assembly and operating instructions accompany every delivery which is in easily handled parcels. On the basis of 2 standard components (the wall section and the ventilated pipe). 14 different drying silos and 78 different storage silos can be made. Assembly can be carried out without previous experience. Two men can erect a silo in one day.

3.8 INSECT CONTROL

Was studied extensively. The description of an insect, its life cycle and the stages were mentioned. Participants were also exposed to ways in which insects get into grain and also primary, secondary and tertiary insects. It was observedthat insects require air, moisture and some amount of heat for survival. Insect moisture requirements was seriously stressed; and ways to reduce this, by drying the grain to particular moisture content which will reduce insect growth and reproduction to the barest minimum.

Individual insects studied included the

| | |
|---|---|
| Granary weevil | Sitophilus granarius |
| Lesser Grain Borer | Rhyzopertha dominica |
| Saw-Toothed Grain Beetle | Oryzaephilus surinamesis |
| Angoumois Grain Moth | Sitotroga Cerealella |
| Rice weevil | Sitophilim Confusum |
| Maize weevil | Sitophilus zeamais |
| Confused Flour Beetle | Tribolium confusum |
| Red Flour Beetle | Tribolium castaneum |
| Khapra Beetle | Trogoderma granarium |
| Pulse beetle | Callosobruchus spp |

Insect control without insecticides was firmly stressed. Most important is Storage Hygiene. Insecticide formulations including contact poisions, dusts wettable powders, emulsion concentrates, smokes and fumigants were also mentioned. Specially mentioned insecticides were Phostoxin and Actellic both of which are highly recommended for use on or around grain with the Kongskilde system.

3.9 RODENT CONTROL

Rodent damage to stored food is of a threefold nature. First, rodents consume a certain quality of the product, secondly they foul a much larger quantity with their excretion, and thirdly they gnaw holes in the containers. Notes on the biology and control of these pests especially the rats and mice like Rattus rattus, Rattus norwegicus and Mus musculus were studied.

3.10 SERVICE AND MAINTENANCE:

Participants were shown sample checking records. These emphasised the need for proper maintenance records and the constancy of chedking faults on the system, be; they minor, before they develop into major ones, which could lead to the total breakdown of the system. Also neglect of minor faults, could cause fatal accidents. Electrical servicing and maintenancé was mainly on the photocells in the heater, the transformers, spark generators, electric motors on the conveyors etc.

The importance of using specified fuel was well discussed. Participants were shown the ignition system in the heater, especially the different types of Danfoss nozzles, their intricacies and efficiences in fuel spray. Participants were also taught how to test for carbon dioxide concentration in the exhaust gass in the heater as a check on fuel burning efficiency and so pollution of the grain vis-a-vis heat output.

4. SUMMARY OF AREAS RELEVANT TO WORK/OBJECTIVES OF THE INSTITUTE

It will be quite difficult to single out any particular area for special mention considering the well planned and skilfully integrated nature of the course. All the fields covered were very relevant to the objectives of the Institute.

5. IMPRESSIONS/OBSERVATIONS

The course was very beneficial to me. My impressions/observations were on evaluation and/of assessment considering:-

whether the course objectives were attained,
opinion of lecutre and general group interaction,
demonstration, practical work and field trips,
subjects to be deleted or added in such future courses and
whether the course objectives were attained, and
Overall assessment of the training programme.

I was of the view that the Objectives where attained to a very large extent considering the duration of the course and relatively short notice given participants to attend.

Even though the group was very heterogenous ie. made up participants with varied academic background problems faced were generally on group basis. There were less conflicts of ideas, interests and personality. During break periods, it was common to see very close interaction between experts and participants.

I also observed that as learning process is varied there should have been more practical demonstrations than we had since almost all the participants have passed their formative years in knowledge acquisition with regard to theorotical learning.

On the deletion or addition of other courses I was of the view that since the course content was extensive with regard to the time available it would have been more proper to invite local companies like ICI or Danafco whose chemicals are used as protectants on or around grain to give practical demonstrations on insects and/or rodent control to complement the efforts of the experts.

Also, I was of the view that the course even though was based on the Kongskilde system, it should have offered participants opportunities to [illegible] design and construct silos using local materials or be geard towards development and application of intermediate technology.

## 6. RECOMMENDATIONS FOR FOLLOW-UP ACTION

The author has had the opportunity to advise on some technical matters and to put to effective use and practice some of the concepts and techniques he acquired at the course since completing.

The chemistry of Crop Protection especially their detection and determination by analytical methods, the basis of selective toxicity and the problem of undesirable side effects, especially in relation to environmental persistance would have been areas the auther would like to be more exposed to in future courses. Emphasis should also be laid on the development of insecticides.

The author strongly recommends the course to the Technical staff who have been invloved in research work on grain handling and storage, more skills, efficiency and understanding, towards effective planning and organisation of storage programmes would be gained.

## 7. ACKNOWLEDGEMENTS

I would like to express, my grateful thanks to the Director, Food Research Institute, and my Head of Division, for making everything possible to enable me attend this course.

Kwame Akorli Vo[illegible]otor.