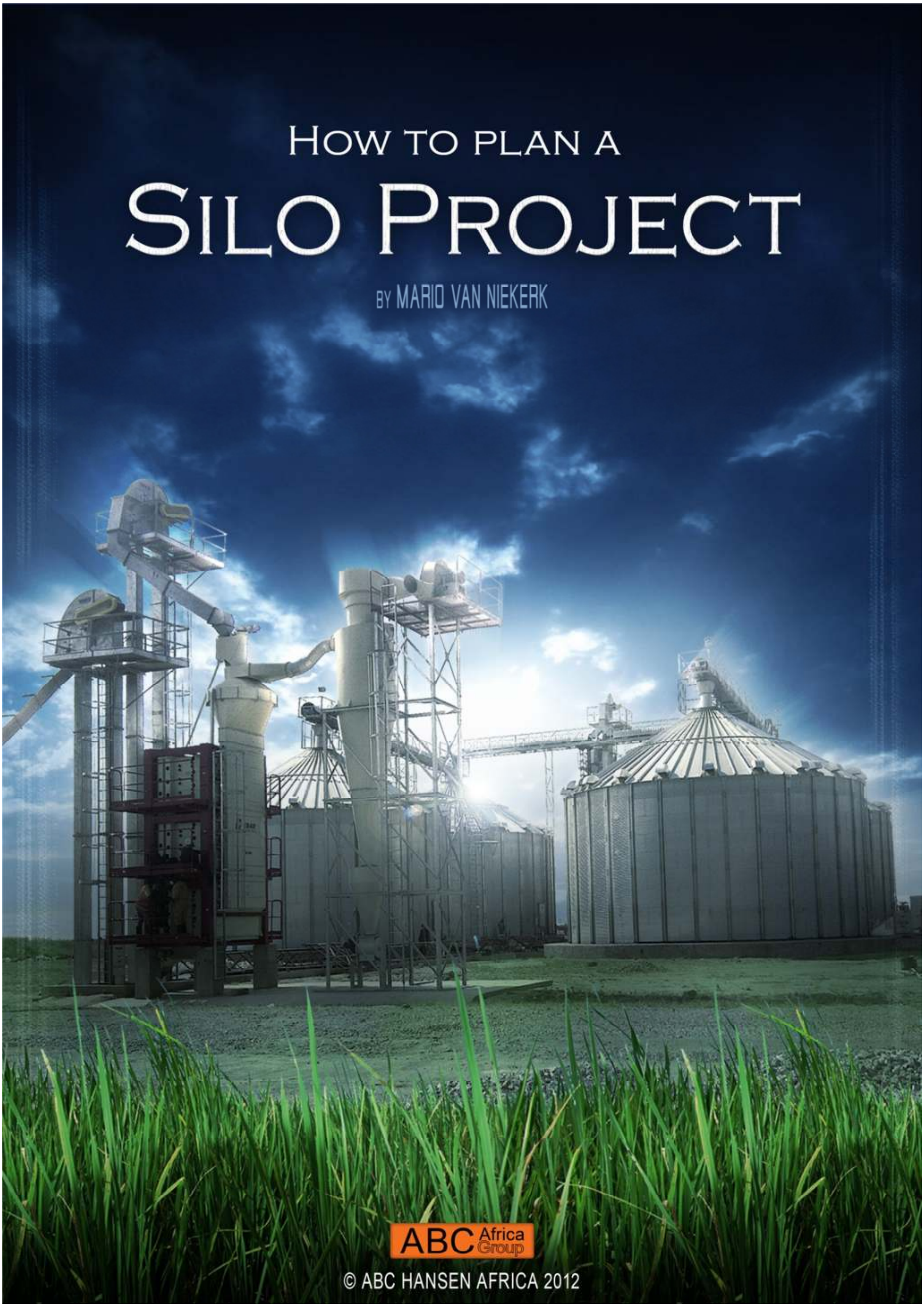
HOW TO PLAN A
SILO PROJECT
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Contents

PLANNING AN ON-FARM GRAIN STORAGE COMPLEX

On-farm grain storage is a viable concept that has been well proven in all major grain producing countries around the world - especially where de-regulation of the grain industry has occurred.

In the USA, most grain is stored on-farm or in country elevators and in Australia a similar situation exists. The extend of on- farm storage in South Africa is not known but is increasing rapidly and has probably kept up with the increase in grain volume produced over the past 20 years since Co-operative storage has not increased significantly since the early 1980's.

In outlining a model, the initial purpose for storing grain should be reconciled from the start with a change in this purpose ie. while it may typically be the goal to use a grain silo complex as flow-through system only in Year 1, circumstances may force a change to this goal in Year 5 and the complex layout should be flexible enough to accommodate this change. This implies immediately that the site should be suitable to accommodate such future requirements. A rule of thumb is to evaluate present needs, then add possible growth over 3-5 years, then double the volume of grain handled and re-plan for this expanded need.

A flow-through system refers to harvested grain being retained in a silo during harvesting and loaded into trucks for delivery to mills or other end users during the harvesting period, and its main purpose is to avoid bottlenecks. Typically the capacity of these bins would be dictated by the harvest rate and the availability of transport. For instance at a harvest rate of 40 tons per hour and harvesting at 12 hours daily with a total 2,000 ton yield, 13 interlink trucks with 36 ton loads would be required 12 hours a day to load daily for just more than 4 days to avoid bottlenecks if a 500 ton flow-through system is considered. The last 500 tons may then be retained in the bin for selling later when prices have improved.

While budgetary constraints may dictate a silo capacity at the bottom end of requirements, it should be flexible enough to increase when the need arises. It then follows that foundation design should be sufficient from the outset to enable higher capacity to be installed on the same foundation. (Silo capacity may be increased (when dealing with corrugated steel bins) by increasing the height of the silo through adding more rings at the bottom.

The question of aeration is often not considered when flow-through bins are stipulated as the initial goal is not to use the bin for medium or longer term storage (3-12 months). If not installed initially though, the addition later on, when required, may be a lot more expensive than it would have been to add aeration at the start, either due to additional civil works, or due to having to install a full aeration floor instead of the channel aeration that would have sufficed when designed into the foundation initially.

Inclusion of a fumigation system is a similar matter to be considered and the advice is to include it from the start.

When considering an intake system, again the initial situation may allow for intake at only 40 tons per hour while future harvesting rates may require intakes of 60 to 100 tons per hour. If limited to the lower capacity, it could result in doubling the cost over a relatively short period. The ease of intake is a further aspect often overlooked until the operator has to undertake this operation himself. A more automated, cleaner and faster system is then frequently called for after a season or two, doubling cost and effort.

The need for drying may not be apparent initially but it should be planned into a complex for later addition, especially in mist belts.

The cleaning of grain may also be a factor that is initially not considered to be of importance but the farmer may realise soon enough that it represents an important value adding activity or an issue that may penalise him seriously if broken kernels are the cause of grain being downgraded. The complex design should therefore from the outset be flexible enough to entertain these additional requirements.

The need for a weighbridge often becomes apparent only later while it should be one of the very first priorities. One of the most important issues is knowing what is going in to your silo, and what is going out! Silos are more secure than bags, but there are still issues of theft, and the only way to detect this is by knowing what is going in, and what is going out. This should be well placed and may even form part of the intake dump pit.

When considering the latter, it is usually more efficient in the long run to keep this above ground level than below grade for reasons of water ingress into dump pits.

Other factors that should be kept in mind when establishing a complex are for instance: How far from the farm residence should the complex be? Considerations are for instance noise, grain dust, truck dust and strangers on the doorstep on the one hand, and control, security and existing infrastructure (roads, electricity etc) on the other hand; Soil conditions, levelness of the proposed site and run-off water management are also factors to take into consideration. While two smaller bins may be more expensive than one large bin, the smaller bins may offer better flexibility for different crops, grades and infestation risks.

In a young farmer’s life, he probably has only two chances to do it right and for a mature farmer only one chance. So, put thought into it, read up, visit existing complexes and get expert advice from known suppliers before embarking on the venture.

SITE SELECTION

Make sure your site:

- Is as level as possible. Earthworks are expensive
- Is not too near your home - dust and noise can be excessive.
- Is secure: Many tons can be stolen from silos before you notice. Damage to grain and equipment may also result.
- Can't be flooded and is elevated high enough with good drainage and above flood levels.
- Has good soil stability: Select a stable area to avoid high cost of excavations.
- Is located at the right spot to allow for expansion. Consider truck and trailer and tractor movement.
- Is accessible from main roads? Are roads reliable during all seasons?
- Has sufficient electrical power - it can be expensive to move far.

Arrangement and layout at the site.

Consider the following:

- Grain handling & cleaning equipment may have to be included later on. Leave room for this.
- Wet holding, drying, cooling, storage bins may be expanded on.
- Dryer if not in-bin drying may be placed.
- Weighbridge may be constructed also.
- Management building may have to be constructed close to the complex.

- Feed processing and storage for other raw materials may be considered later on.
- Bagging systems may have to be installed.
- Roads and its accessibility.
- Fuel storage.

SELECTING A SILO

When selecting a silo the following aspects should be given careful thought and analysis:

1. The total storage capacity has been decided but in how many bins should this be divided into?

When considering this, the crucial elements are:

- How many grades of product would be handled at a given time? Just considering maize, there may be a need for yellow maize and white maize and each may have a requirement for at least two grades. In the case of wheat this may become considerably more complex with many grades and sub-grades and where careful blending of some grades can result in a much higher price per ton. On the other hand, including a cleaning system may bring the maize requirement down to only white and yellow.
- Maize and sorghum and soy beans may be handled at the same time. When a bin is just 10% full, it's occupied as far as any another product or grade is concerned.
- When drying is part of the plan, a wet bin, drying bin and cooling bin may require at least three bins i.r.o. in-bin drying and two in respect of continuous drying to ensure continuous harvesting can be achieved.
- Budgetary considerations may dictate that as few bins as possible be selected as more and smaller bins cost more than fewer and larger bins for the same total capacity, and conveyance and civil works compound this cost further. If this is a consideration however, future expansion should be well planned from the outset.

2. How often would the bins be turned annually as this determines the duty/class of the bin selected?

Most reputable silo manufacturers would be able to suggest several bins in the same capacity – each designed for a specific duty. Farm storage bins, being filled and emptied once, twice or three times annually would be designed differently from bins used in a mill that are filled and emptied weekly or monthly for instance. The latter would require a much stronger bin.

The steel quality used for a specific bin, such as tensile strength is important and the amount of steel used (ie. the total mass of the bin) are significant parameters along with aspects such as galvanising grade (the amount of galvanisation used per square meter or foot) and even more importantly whether the bin is stiffened or not. An un-stiffened bin, normally used for low turn frequency, is often heavier than a stiffened bin designed for more frequent turning as the sidewall sheet are thicker but due to the downward pressure exerted on the sidewalls, a stiffener may be preferred to lower the stress on the sidewall sheets.

3. Should the bin have a flat bottom or is a conical bottom preferred and why?

Flat bottomed bins do not allow for the bin to be emptied only by gravity but requires a "sweep" mechanism (usually a screw conveyor pivoting in a circle around the bin and collecting the grain to the centre of the bin from where it is unloaded. These bins are normally lifted above ground level by its foundation to avoid water damage to the grain. Conical bottom bin of the other hand can have the cone totally above ground (preferred for reasons of elimination of water ingress but reducing bin capacity) or below ground level where bin capacity is increased somewhat while making the grain more prone to water damage. Soil simply moves due to geological and environmental factors, causing cracked foundations and/or other seepage. When selecting a conical floor, ensure that the grain's angle of repose is considered well before the angle of the cone is determined.

The above are all relating to basically flat bottoms but either with flat foundations or with conical concrete foundations. Bins with conical steel bottoms are usually selected for very specific purposes such as for conditioning bins in mills or bins with relative low capacity (usually not more than 1,500 tons) but requiring fast and very frequent unloading or where the product is a bit sluggish in flowing and sharp angles are required. Hopper bottom bins are very expensive relative to flat bottom bins. Hopper bins are also used for storage of meal or flour and such small bins are often seen alongside poultry or piggery houses.

4. What is the optimal diameter of the silos to be selected?

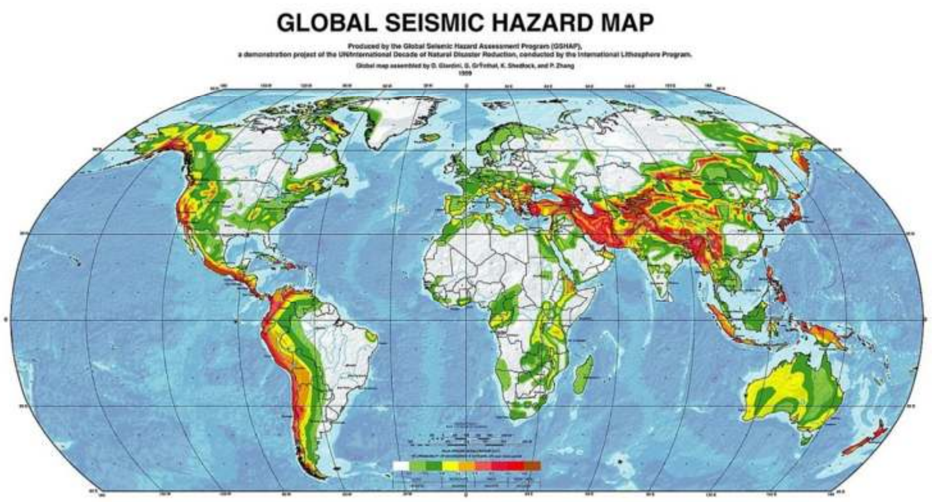
The same capacity silo can be either high and with small diameter or low and with large diameter. A 12.8 meter diameter bin, with 19.51m overall height can be used to store 2,014 tons of maize while a 16.46m diameter bin with peak height of 15.88 meter would store 2,068 metric tons of maize. Factors that determine the cost of a specific silo are for instance the roof area of the silo (the larger the diameter the larger the roof; the foundation (the larger the diameter the larger the foundation area); the height (the higher the bin the heavier die sidewall sheets and stiffeners); conveying equipment (height increases the equipment cost and running cost such as energy to lift the grain).

In the absence of other factors such as for instance high wind speeds, seismic conditions, site constraints, all these aspects above should be thoroughly investigated before a specific silo is selected. A lower silo may also for instance in future be easier lifted to increase capacity. Some classes of silos such as farm storage bins without stiffeners, usually have a height limit to where it may be safely erected, normally 12 to 14 rings whereas stiffened bins selected from the outset may push this to an eventual 30 rings height.

5. How heavy would the conveying equipment and catwalks be which determines the required strength of the silo roof?

Roof strength and whether silos are stiffened or not, determine the support provided for heavy conveying equipment and overhead supporting structures and walkways. Raftered roofs may provide 5 or 6 ton support with regular roofs only 2 or 3 tons.

When silo selection is not properly considered, and not planned for with a longer term view, many problems may occur. In some cases enterprises are sold with ordinary storage silos and the new owner decides to set up a feed mill, utilising the silos for a purpose for which they were not designed and then within a few years, they experience failure of a bin. This could be audited where the origin of the silos are traceable ie. If it was originally sourced from a reputable supplier and installed by a reputable dealer who can, years after the event, still supply information as to the design parameters of the bin. This not only provides the new owner with certainty as to its potential, but allows the seller to obtain top money for the development and if the original purpose requires an upgrade, it is a known quantity that can easily be rectified.



The seismic zone in which the complex is located will determine the engineering of the bin. Choose the right supplier.

Summary: Silo Selection

How many grain types grades would you handle?

If only one type & grade one bin is sufficient

If more than one two or more bins is better.

One large bin is always cheaper than two smaller bins for the same capacity but is it functional? A large bin 10% full can only be utilized for one grade and type of grain.

What quality silo am I offered? How is this evaluated? Inspect and research:

- Workmanship by appraising other similar installations,
- Galvanizing: Iis it consistent (its only as good as the thinnest or poorest part),
- Precision: If excessive drilling is needed to line up holes, galvanizing & silo strength is damaged,
- Steel strength (mild steel vs. high tensile strength (65,000psi is the norm)
- Quality of fasteners and seals. This can have obvious quality differences. Seals are very important and should be tolerant to harsh conditions. Fasteners should be well galvanised to avoid rust transfer into the sidewall sheets.
- Corrugation length (the longer the corrugation and the lower the profile, the weaker the corrugation and less steel is used than for a deeper and narrower profile. (Compare a 4" vs. a 2.66" corrugation)

Who do I deal with and who is the erector?

Known suppliers erecting their own silos should be preferred in general. Subcontractors and indent agents often leave you with no security after an installation has been incorrectly completed.

How important is price?

What brand am I buying? While small brand silos may be suitable, the really world class large scale companies would give you more peace of mind. Avoid developing world manufacturers and avoid brands not used in the major grain producing countries. It's a project that should serve you for 30 years, buy on quality, not on cost. Even a 15% price difference does not warrant a poorer quality silo. Keep in mind, the silo itself is finally only around 25% of the project cost. The remainder consist of civil works, freight costs, conveyance, installation, electrical switchgear, fumigation systems, aeration systems etc.

What types of flat bottom silos are there?

(Good manufacturers will provide a choice of silos, each for its own purpose and at its own cost, such as:)

- Farm storage bins: Purpose made to fill and empty up to 5 times annually.
- Drying bins: Purpose built for drying with heavier plates at the top rings to accommodate stirring equipment. These bins can be filled and emptied 5+ times. Normally not designed to be higher than 12-14 rings.
- AgCom Storage Bin: A Crossbreed between the Agricultural bin and a Commercial bin. With the ability to go higher, with thinner sheets than un-stiffened bins but with stiffeners.
- Heavy duty storage bins: Just what it says, with thicker wall sheets but without stiffeners, normally built not higher than 12 -14 rings. Heavier than commercial bins and able to be erected over conical floors.
- Commercial "Super Bins": Stiffened and used for higher bins - 14 rings to 30 rings high. Normally this type of bin should be selected. It may be 5-10% more expensive than a farm
storage bin. Designed to be turned 10-15 times annually.
- Working commercial bins: Loading and unloading rates of more than 20 times annually.

An un-stiffened bin: Farm/drying/ heavy duty bin

A super bin, stiffened

HOW DO I COMPARE PRICES?

Make sure you compare apples with apples.

- Capacity: Make sure you work on cubic meters rather than "tons". Tons are not exact and can apply to various arbitrary densities. Some sellers include compaction of grain in their "tons" capacity. Others include the space in conical bottoms as "tons capacity" when quoting silos.
- Quality: See previous sections.

Do not necessarily buy the least expensive bin. It's a 30 year investment. Buy the best quality for the purpose to be used. Consider galvanising thickness. This can vary substantially and may mean the difference between a 30 year and 40 year lifespan. G95 (275gr/ square meter) vs G115 (at 350 grams per square meter) are regular differences. And this should not only relate to roofs but to sidewall sheets as well.

What is included? Inside & outside ladders? Eave platform? Spiral staircase rather than only outside ladders? Rest platforms? Special OSHA certified ladders & platforms? Roof stairs vs only roof ladders ? Anyone with slight vertigo would not like a roof ladder and roof stairs would be preferred. All these items cost money but may improve convenience, safety, maintenance ease etc.

Are there any special items for safety included? This may include a hook point in the centre of the bin to attach a cable to where a safety harness can be attached to in order to recover a person that has run into trouble inside a filled bin. An eave platform for instance makes any recovery much easier and allows a person to monitor the worker inside the bin. Are safety notices supplied in order to ensure your liability is limited?

What I the load bearing capacity of the silo roof? You may wish to install heavy catwalks and conveyors on the bins and should be sure it can bear those loads. Catwalks often span more than 20 meters between bins so only the bins should be able to bear this load.

Hopper bottom bins are always a lot more expensive than flat bottom or rather bottomless silos. Large capacity hopper bins are only selected when the grain is turned frequently, is wet, is used for conditioning in milling etc. Sometimes seed quality grain or other expensive grains are also stored in hopper bottom bins to avoid damage.

The tensile strength of the sidewall sheet will give you a clear idea of the quality of the steel used. Mild steel silos may have much thicker sidewall sheets but does not have the same flexibility to return to its normal form when deformed. The continuous high and low stress levels when the grain is loaded or unloaded, furthermore creates metal fatigue and a bin with low tensile strength will fail faster.

Buy the best bin! *The alternative …………*

………………………………too ghastly to contemplate!

Before the fall!!!

SELECTING A GRAIN CONVEYANCE SYSTEM

The first part of this series was about the planning of a grain storage centre and summarised some of the issues that we are exploring further here. The second part covered the selection of a silo and this part will discuss aspects such as silo and a grain conveyance system selection, aeration & drying parameters and options before we finally bring it all together in an installation with civil works, and what that involves.

Grain conveying in a silo complex is arguably the most important aspect in planning a system. This will determine and address:

- the capacity of intake and unload,
- the energy costs,
- the bulk of the maintenance and replacement cost
- the frustration level indicator ie. Bottlenecks; accessibility; ease of cleaning; creation of dockage; wet material etc.
- cleaning intake and load into the system
- drying intake and load into the system
- dealing with trash

All conveying systems would be a combination of several types of conveyors. We would concentrate on the most important combinations, starting at the beginning:

a. Intake dump pit. Of major concern here are the size of trucks / grain cars to be catered for ie. side ore dumpers requiring 8 meter long dump pits or own grain cars with conical bottom chutes requiring no more than one square meter intake area, and all in between. With a design of 45 degree angled slopes to allow for fast sliding of even wet grain, the size of the pit naturally requires either very deep levels or conveyors inside the pit transporting the grain to the intake point. Usually either screw conveyors or chain conveyors would be located inside a pit with a service area required in the pit and a water trap with pump. Where suitable it is recommended that the pit be as shallow as possible as water ingress is a constant problem with deep pits. A good rule is to increase the intake conveyor capacity and limit the size of the pit. At intake capacity of 100 tons per hour, a 12 ton grain car can be unloaded in 7.2 minutes – why build a 20 ton capacity dump pit if the harvesting rate is only 40 tons per hour? At 8 minutes per dump, around 90 tons per hour can be handled.
b. Selecting a main conveyance system is determined by the number of vertical lifts and horizontal distance the grain needs to be conveyed for as well as other criteria as listed below.

i. Bucket elevators are able to lift grain vertically high at relatively low energy requirement. If the grain is then required to flow by gravity to the various bins, it needs to lift the grain high to each the required angle. It is always used in conjunction with either chain conveyors, belt conveyors or screw conveyors.

   1. Positives:
      a. Low energy & high efficiency.
      b. High capacities can be reached.
      c. Relatively low maintenance.
      d. Low breakage of grain (on the vertical leg but not when feeding the bins by gravity).
   2. Negatives:
      a. Relatively expensive
      b. Poor system when using gravity to load bins for high capacity and fast turnover complexes.
      c. High maintenance on spouting on discharge if not lined.
      d. Must still be used with other horizontal conveyors.

ii. Chain conveyors were traditionally used for horizontal conveyance only. It can however now be adapted for inclines at 45 – max 60 degrees. Great for loading bucket elevators or coming from the dump pit. Good for the connection between the bucket elevator and the top of the bin, thus not requiring tall elevators with down spouting as the elevator outlet can be max the height of the grain bin.
   1. Positives:
      a. Lower maintenance than augers.
      b. High capacity.
      c. Can incline.
      d. Relatively low dockage created.
      e. Long distances can be covered.
   2. Negatives:
      a. Expensive with lots of plate work.
      b. High energy requirement.
      c. Does not jam easily and can easily be “un-jammed”.
      d. Requires substantial supports as catwalks and towers as it is usually heavy.

iii. Belt conveyors are normally used for products that are brittle or are conveyed wet or that require high capacity.
   1. Positives:

a. Low maintenance.
b. High capacity.
c. No jams.
d. Very efficient.
e. Very long distances covered.
f. Can deal with wet products.
g. Can easily start up under load.

2. Negatives:
   a. Expensive – usually only because it requires additional coverings when outside.
   b. Needs covering when outside for both products and to protect belting.

iv. Screw conveyors - also called the Archimedes screw. Almost good for all jobs but never the best choice unless the budget is the only consideration.
   1. Positives:
      a. Many applications, inclined and horizontal.
      b. Low cost.
      c. Can start under moderate load.
      d. Limited capacity – usually not used for more than 100 tons per hour.
      e. Can vibrate if running fast and usually noisy until under full load.
   2. Negatives:
      a. High maintenance on tube and spiral.
      b. Very abrasive in grain with quite high dockage created.
      c. Fairly inefficient as the incline increases due to fallback between the tube and the screw and requires relatively high energy.
      d. Jams not uncommon and pulling the spiral from the tube can be a job.
      e. When over longer distances, plenty of internal centering support bushes or bearings required.

v. Air conveyance is popular for some applications such as operations without electric power where tractor PTO's can drive blowers, where horizontal distances are far, where mobility is required, where no or little infrastructure exist. Does not require grain dump pits.
   1. Positives:
      a. Mobility with either PTO or engine drives.
      b. Clean-ups where grain has spilt.
      c. High capacity 80 – 150 tph is obtainable.

d. Ideal for grain dams, field loading of trucks, remote silos, sheds used for grain storage, bunkers, silo bags unloading and clean-up.
e. Used for discharging vessels also.
f. Inexpensive when considering the number of other conveyors it replaces.
g. Low grain damage when used by itself ie not in conjunction with an auger on the blow end as is common is cheaper air conveyance systems.

2. Negatives :
   a. High power consumption per ton conveyed.
   b. High damage to grain only when used in conjunction with screw conveyors as some equipment has a suction leg plus an auger discharge leg rather than a suction and blow leg.

vi. Chain Tube loops (Grain Pumps) and conveyors consist of tubes into which a chain and paddles are running with sprockets on the corners, forming either a square or rectangular loop or alternatively two tubes one above the other with one sprocket on either end or at an incline point forming a horizontal or 80 degrees inclined conveyor. This type of conveyor system was developed in the USA some 18 years ago and is used all over the world in not only farm silo complexes but large commercial complexes with capacities in excess of 450 tons per hour. The last 5 years have seen major increases in its usage.

1. Positives:
   a. All the advantages of a chain conveyor and none of the disadvantages.
   b. High capacity 100tph on a 8” loop up to 450 tph on a 14”.
   c. Does not require elaborate support systems.
   d. One or two motors drive entire complex. Less switchgear.
   e. Lowest damage to kernels of all conveyors.
   f. Very low maintenance.
   g. Used for vertical and horizontal conveying.
   h. Low power consumption per ton conveyed.
   i. Can be efficiently used in sheds for flat storage.
   j. Can discharge directly into loop from elevated grain dump pit.
   k. Less expensive than a bucket elevator and chain conveyor- or auger combination.

2. Negatives:
    a. Start-up under full load may be difficult and the vertical leg may have to be cleared of grain (easily done) if stuck under load.
    b. Moderate grain damage only when not operating at full capacity.

When selecting a conveyance system for a larger complex, select a company that can offer all options, then get quotes on all options and consider the pros and cons. Ensure you select higher rather than lower capacity. Ensure the system is as simple as it can get. Choose a low maintenance low grain damage alternative. You will live with this equipment for a long time, don’t let a 10 or 20% price differential dissuade you from the better alternative.

Bucket elevators & belt conveyors

Mobile auger

Grain loop without catwalks

Grain loop with catwalks

Pneumatic conveyance

SELECTING AN AERATION SYSTEM

If a bin is aerated, the correct air volume and pressure should be selected for the type of grain.

The correct floor and blower will accomplish this.

Floor types include:

- Full floor aeration usually smaller diameter bins and drying bins.
- Flush floor aeration: Channels in various designs in the concrete floor of a silo such as double I; Y; E, square pad etc. A reputable supplier will recommend the aeration most suited to your circumstances.

Fan selection is determined by pressure and volume air and can either be:

Axial fans (high volumes but low pressure so not recommended for high bins – max 3” static pressure, noisy, less expensive than centrifugal fans)

High or Low speed centrifugal fans. (Higher pressure of more than 4”, low noise level, more expensive than axial fans. Usually recommended for small grains and in-bin drying.

The static pressure against which a fan operates is affected by the following:

- Grain type: Smaller grain kernels and grain shape has more resistance than larger grain (compare wheat vs maize).

- Airflow through grain: Doubling the airflow triples airflow resistance and requires up to 6 times more kW power.
- Grain depth: This relationship is linear ie one meter additional grain depth would require directly the equivalent higher resistance.
- Fines and foreign material: This has a large impact on resistance as it fills the gaps between which the air should flow through the grain.
- Grain compaction: This is determined by moisture content, filling method, grain depth.
- Back pressure brought on by insufficient airflow out of the bin. A provision should be made to have at least $300mm^2$ / 28 cubic meters air per minute.

Why is aeration required?

- Every bin has a cold and warm side. This results in moisture migrating through the bin with condensation and concentrating in a section of the bin where the grain becomes hot and damaged and which may lead to spontaneous ignition eventually.
- Heat damaged grain cracks and eventually disintegrates. In the case of wheat, the baking quality is entirely destroyed.
- Aeration can also dry grain through a process called dry-aeration where large volumes of air carries moisture away with it. Without a stirring or turning mechanism, very low heat should be applied so as to avoid heat damage to the bottom layers of grain.
- Pests and insects can also easily and effectively be controlled by using a low pressure fumigation fan to suck the poison vapour from the top of the silo and introducing it in the bottom via the aeration floor or channels.
- Aeration is recommended for any grain being stored for more than 3 months, it is important to ensure that your system can be converted to incorporate aeration before you buy.

Aeration fans with small fumigation fan.

SILO FOUNDATION OPTIONS & THE INSTALLATION PROCESS

It's important to ensure that soil stability is at the required level before doing anything else.

The silo supplier should be able to offer a complete service, from start to finish. Planning the system, proposing alternatives, designing foundations, obtaining engineering specifications, laying the foundations or subcontracting the laying thereof, providing tools and equipment , erecting the grain storage facility, supplying and specifying electrical control panels, cabling and electrical installation including provision of a COC (certificate of compliance), getting engineering certificates for structural and civil works, and providing after sales support.

About one and a half month before the physical erection of the silo, the team should arrive at the site with their equipment and start preparing the site. Before this, the soil tests would have been done. Now the re-bar would be placed and foundation will be cast, the size and depth depending on the resistance of the soil and the size of the silo.

A ring beam is designed to carry most of the load of the grain as it is loaded and unloaded. This is where most pressure per centimetre is exerted. The silo sidewalls should be positioned in the middle of the ring beam. The ring beam width increases as the pressure increases due to the silo height and the silo capacity. The thickness may also increase and the re-bar quantity and strength increases as the ring beam capacity increases.

In the centre part of the foundation, inside the ring beam, a floor is cast with an expansion joint between the ring beam and the floor. The grain pressure over this area is more distributed over the entire floor and exerts much less pressure per square centimetre on the floor. It is therefore much thinner than the ring beam. It still has re-bar specified to it.

Channels may be specified through which aeration takes place. Alternatively a full floor consisting of supports and specially designed aeration planks are erected over the flat floor. In the case of a conical floor. Aeration channels are cast in the floor and are connected along the ring beam with a circular duct into which the air is blown from the outside of the bin.

After the foundation has been cast, it is left to cure for a minimum of 28 days. After this period a team arrives once again, and erection of the silo can begin in earnest. Building their way down from the roof, sheet by sheet and row by row the team assembles the silo. Just before the silos is complete, and the aeration floors and fans are being installed, the transport systems are installed, be it a bucket elevator, screw augers, a grain pump or an air transport system. After the transport system has been completed, and the silo is secured to the foundation, the electrical installation has been completed and the system tested, the customer is ready to start harvesting and loading the silo.

Soil bearing capacity should be at 150kPa. If below this, an engineer should recommend a stabilizing procedure of the soil. This may include digging right through the level and backfilling and compacting the soil, to merely digging and stabilizing the soil with a cement mix and compaction. Foundations should cure for 5-7 days before the silo can be erected thereon and another 21 days before grain can be loaded therein.

From start … *to finish.*

Silo floor options:

Flat bottom silos.

Why the first choice?

- Over the silo life of 30+ years, any below ground level conical floor will leak because of soil movement, water table rising, floods etc.
- An above ground level foundation will stay dry and in good shape for many years.
- Cheaper & easier to construct.
- Full floor aeration can be properly installed. Poor aeration in conical silos.
- Movement inside the silo is easy.
- Sweep augers eliminate the need for collection in a conical bottom.
- No sump pump and water trap is required.

Conical Silos

Why would you consider a conical below ground level floor?

- A few extra tons storage is gained.
- One transport auger less can be used for small installations.
- No sweep auger is required.
- For short term storage not requiring aeration.
- For very fast turning bins.

Conical floors may also be erected above ground level. This is a better alternative than below ground level but is vastly more expensive than flat bottom floors. While concrete silos can easily be erected on such floors, it is more difficult to erect galvanised silos on such floors, while not impossible.

In large commercial silos this is often a preferred choice. The floor may also have several cones inside along the unload conveyor route, thus allowing for a lower cone. Aeration likewise presents problems with these floors.

GRAIN DRYING OPTIONS

Drying is a very extensive subject. For purposes of this publication it would not be discussed is detail but a general overview would be given.

Grain is harvested in too wet a state and should therefore be dried, for several reasons such as:

- The season warrants that another crop be planted especially in the case of irrigated fields where the turnaround pressure is big.
- Grain takes too long to dry in the field as rain or fog is prevalent.
- Cash is tied up in grain that can be sold.
- Some parts of fields are still with high moisture content while other parts are dry.
- Higher yield is obtained and less kernels are wasted during harvesting when moisture levels are higher than can be safely stored.
- The risk of grain deteriorating on the field is high.
- Fire risk is important in some areas.
- Insect damage such as ants may cause a farmer to consider drying. Other animal damage may pose a threat.
- Theft is some areas are endemic.

The drying process basically works like this: warm air is introduced into the grain. As heat expands the air, more moisture is trapped inside the larger volume since moisture migrates to the drier area. It is then removed from the grain inside the bin.

Grain at 24% moisture and at an average 24 degrees C, has a lifespan of only 4 days. Inversely, grain at 15.5% moisture at the same 24 degrees C, has a life of 60 days. This is the total time, from harvest to the time it can be used. It does not include the time the miller needs to store the grain before milling for instance. Therefore are two elements namely moisture on the one hand and temperature on the other. Holding wet grain should therefore be in the coolest possible environment to retain life – much like food outside and inside a fridge. While the cool air of aeration fans in a wet holding bin may accomplish an extended life on the one hand, it remains critically important to get the grain to safe storage moisture content as soon as possible.

Before drying, grain should be cleaned in order to remove fines and broken kernels which hamper air flow through the grain and thus reducing drier capacity. See section on cleaning below.

Moisture should be tested prior to taking in grain. Sampling should be done representatively throughout the field being harvested. Note that warm grain can cause incorrect reading on a moisture tester.

Holding wet grain is important in any drying facility as it enables the operator to dry grain on a continuous 24 hour basis when harvesting has ended for the day. Normally dew settles on the grain in the evening and prevents late night harvesting. Wet grain should be aerated all the time to prevent deterioration.

Grain should be cooled after high temperature drying. Rapid cooling of grain in a continuous flow dryer may result in stress cracks. Delayed cooling usually takes the form of in-bin cooling and necessitates another silo with perforated floor and aeration fans. Dry-aeration is another method of cooling grain in the same bin after it has been batch dried while a combination high/low temperature drying can accomplish the same result.

If in-bin drying is used rather than hot/cool drying, 10% fuel can be saved and 33% capacity improvement in the dryer can be achieved. The grain should be cooled immediately once it hits the cooling bin as otherwise condensation against the bin walls and roof would occur.

With dry-aeration, energy cost can be reduced 15 – 20% and dryer efficiency 50-70%. Hot grain is removed to the cooling bin immediately after drying but cooling is delayed for 4-12 hours for steeping and tempering. Less stress cracks are found this way. As the grain cools, the air warms to the grain temperature and as it warms, it expands and collects moisture from the grain and forms a front moving through the entire bin. It is normally required that warm grain tempers at east 4 hours before the cool front reaches it, so the timing for starting the cooling fans should be correct while filling the bin with grain. While condensation will take place on the sidewalls, it only becomes a problem if the grain is stored in the cooling bin. As it is unloaded however, the wet grain will blend with the dried grain sufficiently to avoid problems.

In-bin drying has become the favourite way of grain drying, especially for on-farm and smaller commercial systems. The bins are used throughout the year for storage while a continuous dryer may work only for a few weeks a year.

In-bin drying would normally necessitate a wet holding bin, a drying bin with a stirring device or a drying compartment in the roof of the bin, and a cooling bin. In this way very hot air can be used for drying and 24 hour cycles can be accomplished. Bins with roof drying compartments can be electronically timed to release the grain after a specified period and the loading and unloading system can be started by timer. The grain is cooled when it is released into the bin from the roof drying chamber. The grain is batched into quantities relating to the bin diameter. A 30’ bin diameter would allow +- 37 ton batches at a time.

In-bin drying systems with stirring machines are much less complicated.

Another in-bin drying method is on-floor bin-batch drying without stirring equipment. Layers of no more than 1.25 meters should be dried at a time. Usually the bin is gauged to allow for one day’s harvest to accumulate and to dry over 24 hours before being moved to the next bin.

Grain spreaders are usually required for in-bin drying to ensure grain is spread over horizontal layers and not peaked in the centre of the bin.

High temperature self contained dryers can be either manually batched, automatically batched or continuous flow. Lower capacity dryers may be portable and may have hot and cool cycles in the same dryer.

A stirring machine used for in-bin drying

A large complex with continuous drying

Flat storage:

This refers to grain being stored on the ground in various forms, from simply heaps to bunkers to grain dams to sheds. I would also classify silo bags under this category.

The most important factor here is that the grain should not require any cleaning or drying when stored. It should be very dry – below 12.5%. It should also be stored in all parts of Africaduring winter months only since there is usually no or very rudimentary aeration with grain reaching high temperatures under tarps only. In most developed countries grain stored under these conditions would be used for industrial applications such as ethanol at best. Nutritional value is just not the same as properly stored grain, unless perhaps under the northern hemisphere's fall, winter and early spring conditions.

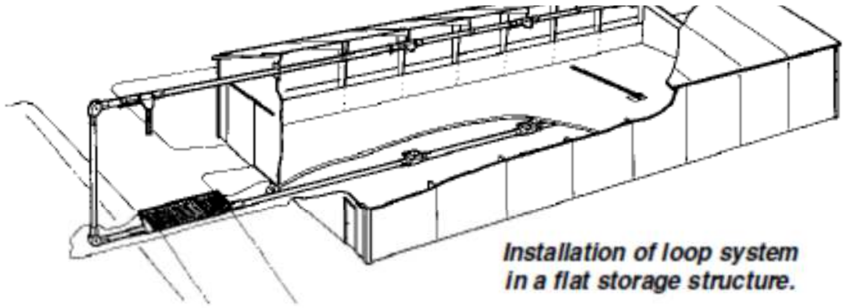
Grain in flat storage is usually turned once only because of the difficulty in unloading. Loading is not too difficult with high capacity belt, tube and screw conveyors in mobile execution filling the storage from the sides in the case of bunkers and heaps and dams. Reclaiming is usually done by means of front end loaders with the resultant damage to grain under the wheels, spillage of oil and diesel etc. Grain in flat storage is difficult to manage. Optimum drying is difficult because grain is evenly spread. Ground moisture requires a firm barrier and the floor should be raised at least 150mm abve ground level. Drainage on the sides, rodent proofing and bird proofing can be challenging. Fumigation can be very difficult and ineffective. Dirt, sand, grease, fertiliser not cleaned up properly, pesticides previously stored, can make matters worse and can be outright dangerous.

Grain in silo bags are handled a little easier with made to purpose equipment to load and unload the grain but are still subject to heat damage, vicious competition for nutrients by fungi and bacteria, rotting due to moisture ingress caused by rodents, hail, theft etc.

Sheds can be properly mechanised with aeration, effective sealing, fumigation, proper loading and unloading equipment in permanent installations. The question of whether this presents a less expensive option to silos are however not clear and is usually only an option where an existing shed is underutilised or not utilised at all. Most important is not to let the dual use of a facility foul the use up to the extent that it is not suitable for either purpose.

Most dry grains peak at an angle of between 18 and 28 degrees with maize at 23 degrees and soybeans at 25 and sorghum at 29 degrees. This information should be used to calculate the volume and hence the mass of the grain in storage. The heap should be broken up into three separate parts where each part's volume is determined. Ie the rectangular part up to the eave or supporting structure above ground level, the triangular heap in the centre and the two triangles at either side.

Grain dams should be used as a very last alternative unless properly mechanised. Suck and blow systems can be used here efficiently and is probably the best method for filling and unloading these contraptions. Loading by means of augers are easy but auger unloading becomes a menial nightmare.



Installation of loop system in a flat storage structure.

Safety

As with most things, safety has become a more important aspect of any business' operations than previously. Probably not because a life is valued higher but probably because management should be smarter and the gap between the haves and have nots have increased to the highest level in history and haves or management, can't be seen to be, as in the past, careless about the welfare of workers. In many cases the worker is the farmer or manager himself and he or she should be wel informed about the way to prevent unnecessary accidents.

Silos are not safe environments to work in. Many dangers lurk where powerful equipment is used. Proper signage is the first step. Make sure your silo company has the signage and displays it where it should be displayed.

The main dangers surrounding silos are:

1. Moving parts and equipment.
    - It is important not to wear loose clothing near rotating parts.
    - Shields and guards should always be replaced and kept in good condition.
    - Electrical lockout should be placed at every machine.
    - Emergency stops should be placed near all sections of the plant.

2. Height:
    - Silos can be very high and when working up there safety harnesses should be worn.
    - A maintenance man should never work alone on silos and catwalks.

- Do not work on bins or structures or outside equipment during or just after rain or snow.
- Wear protective clothing. Including hard hats when someone is doing maintenance in high areas.
- Ensure catwalks and towers are properly maintained including painted, fasteners are checked for rust, crucial welding is checked, warping etc.

3. Inside silos:
    - Never enter a silo alone. Always have someone at the hatch or door.
    - Never enter a silo that has been fumigated until all hatches have been opened for a substantial and prescribed time, and aeration has been switched on to remove all poison vapours.
    - Never open a top hatch after fumigation and bend to look into the silo. Open hatch and move away immediately.
    - Never enter a silo unless all conveying equipment has been locked out at both the main control panel and the equipment itself. This includes fans.
    - Always station a person at the main control panel when entering a silo to ensure no-one turns on the system. When unloading while inside a silo, the person with be pulled under the grain and will suffocate.
    - Always enter a filled silo with a safety harness and ensure there is a hook inside the silo roof where a cable runs through and is attached or controlled from the outside by an assistant to avoid entrapment inside a collapsed hole in the grain. This hook should be installed by the silo supply company. Insist on this.
    - Always enter silo with a dust mask.
    - Suffocation is very easy when fans are started while inside a filled bin.
    - Be alert for possible dust explosions. Never enter a silo during thunder storms. Never smoke near an opened hatch. In fact ban smoking inside the entire silo complex.
    - Dust explosions happen when the air is saturated with fine dust and an event triggers an expansion of the air within a confined space.
    - Never do maintenance with cutting torches or welders or angle grinders on equipment or inside a silo with dust around. Dust can settle on corrugations, a tremor caused by lightning or thunder can release the dust into the air and a spark can ignite this mixture.

4. During unload:

- Never enter a truck or grain car being unloaded.
- Never work near any rotating part.
- Ensure the unload area is well ventilated either mechanically or naturally.

5. General:
    - Grain dust can be slippery when wet. Ensure floors, steps and stairs in the complex are kept clean and has a non slip surface.
    - Wear protective clothing and accessories including hard hats, ear plugs, eye protection when moving or working.
    - Ensure bins, towers and catwalks are properly earthed.
    - Replace belt and chain and all drive covers.
    - Read operating instructions carefully.
    - Ensure that the silo supply company provide you with training in operating the system.

Finally:

When making a decision to erect a silo complex or perhaps just one flow-through bin to allow continuous harvesting, be sure to spend the correct amount of time and effort in planning.

If you have spent too much time and the supplier you have selected cautions you that you may be too late for this season due to lead times etc. go ahead and develop the project but do not anticipate and push to have it up before harvest time or select your second or third choice simply because they are quicker.

Keep in mind that this is a 30-40 year investment, actually done for the next generation.

Storing your own grain in a proper silo system will save you money. Most systems have a payback period of 3-5 years and systems can normally be financed over 5 years.

ABC Hansen Africa (Pty) Ltd is part of the ABC Africa Group and plan and erect silos throughout Africa and with sister companies (the Cormall and Skiold Groups) in the agricultural equipment business in Denmark and with branches and offices and operations in the UK, throughout Scandinavia and Europe as well as the Ukraine and other eastern European countries.

ABC Hansen Africa imports silos and grain handling equipment primarily from Global Industries in the USA which incorporates in one group the following major manufacturers:

MFS, York, Stormor, Hutchinson, Mayrath, Neco, Brownie.

ABC Hansen Africa also manufactures grain handling equipment, cleaners and milling equipment in its premises in Pretoria. It also represents other major manufacturers such as Sweet Manufacturing and InstaPro from the USA and Walinga from Canada.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