SILO PROJECTS

ON FARM AND COMMERCIAL STORAGE OF GRAIN

Considerations when planning a silo complex

What is your main purpose in storing grain?
This would dictate your requirements
and determine the type of silo you should consider to purchase.

SILO STORAGE CONSIDERATIONS

-Short term storage and flow through silos – may be turned frequently but stand empty most of the year.

-Flow through and long term storage for at least part of the crop.

-Long term storage – more than 4 months.

-Processing – turning the bin often as for feed mills and fine mills.

-Processing – turning the bin two or three times annually.

Galvanized corrugated steel silos can be classed as:

Farm storage silos - Usually not turned more than 2-3 times annually, not very high (max +-14 rings) and built on flat foundations. Usually not stiffened but with thicker sidewall sheets.

Drying silos – As with farm storage silos but able to be turned more frequently and with thicker wall sheets especially at the top rings to allow for stirring equipment to be installed.

Heavy duty silos – As farm silos un-stiffened and generally not higher than 14 rings but able to be turned yet more frequently and can also be erected over conical foundations and as such, still heavier sidewall sheeting.

Also to be used in areas with adverse seismic conditions.

Commercial silos – stiffened silos (inside or outside stiffeners) usually higher than 14 rings and up to 32 rings normally, can be turned many times (15+ times annually), used in adverse seismic conditions.

Agcom Silos Sometimes called Farmcon etc – Stiffened silos but with lighter stiffeners and lighter sidewall sheets, with more fastener rows, with wider sidewall panels, can be high silos and turned less frequently than commercial and more than drying silos.

Other considerations when selecting a silo are:

-The height vs the diameter of a silo – High silos require thicker sidewalls, wide diameter silos require wider roofs and bigger foundations. Find the optimal configuration.

-The pitch of the corrugation – the sharper the corrugation the stronger the profile. Silos should be designed to allow for these strengths vs weaknesses.

-The mass of the silo – how much steel went into the manufacture of the silo.

-The tensile strength of the steel sheets – the higher the tensile strength the easier the sheet would revert back to its original form when deformed.

- The amount of galvanizing applied to the silo and the evenness of the galvanizing – its only as durable as the thinnest part. “Tropicalized” silos may have heavier galvanizing and manufactures may differ notably on this.

-If side-drawing is required, the silo must have a special stronger design. If side loading is required, the design must likewise be stronger.

- If heavy walkways and heavy conveying equipment are used, the silo roof bearing capacity must be sufficient.

-Seismic conditions may require heavier silos and foundations.

Capacities of silos

- Apart form the above considerations, silos are sold by capacity. The best way to determine capacity and to ensure different manufactures are matched, insist on knowing the cubic meter capacity based on a flat foundation.
- Factors used to determine a tonnage includes:
  - The hectoliter mass of the grain – maize may have a 72kg/100liter mass while sunflower only 46kg and wheat 80 kg. Its therefore vital to know what basis the tonnages were arrived at when quoted.
  - Compaction in the case of maize may be 2% which is normally added to the mathematical tonnage capacity reached.
- Be sure you compare the right sizes.

Silo Accessories

When evaluating silos, many accessories may be included or excluded such as:

Inside and outside **ladders** – regular straight ladders or spiral staircases on the outside, with or without: rest platforms, eave platform, OSHA back-guards, roof stairs with or without handrails.

Is a **bin step** included to enable you to easier get through the silo door.

What is the **height of the door**? If only one ring high, you have to squeeze in through a 700mm high door, with double ring height, it's a comfortable 1,6 meter high door.

Sealing – how is the eave sealed from the sidewall – is it airtight to allow for fumigation and does it avoid birds nesting there and wind driven water penetrating.

Is a sealing **strip** included between the bottom the silo and foundation floor?

Are the **doors** properly sealed? Can the **gooseneck vents** be sealed if fumigation is added later?

These factors, if not included in all offers, may involve substantial differences in cost

and may penalize one supplier unwittingly.

How many bins should be used to store a given capacity of grain?

- How many grain types / grades would you handle? If only one type & grade – one bin may be sufficient.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 / grain
- If more than one – two or more bins should be selected.
- If a flow-through bin is to be used only, one bin is usually sufficient.
- If a dry-aeration system is to be considered, three bins is usually preferred (discussed later).
- REMEMBER: More than one bin requires higher spending on conveyance as well as civil works. Be sure what your needs are.

What does a silo complex normally consist of other than silos?

- Aeration
- Drying
- Pre-Cleaning
- Intake systems
- Unload systems
- Foundation options
- Civil works

Aeration of grain

The life of grain at various temperatures and moisture:

Storage days at various temperatures and moisture content								
Grain	Moisture content, % on wet basis							
Temp °C	15.5	18	20	22	24	26	28	30
-1.1	2,276	648	321	190	127	94	74	61
1.6	1,517	432	214	126	85	62	49	40
4.4	1,012	288	142	84	56	41	32	27
7.2	674	192	95	56	37	27	21	18
10	450	128	63	37	25	18	14	12
12.7	299	85	42	25	16	12	9	8
15.5	197	56	28	17	11	8	7	5
18.3	148	42	21	13	8	6	5	4
21.1	109	31	16	9	6	5	4	3
23.8	81	23	12	7	5	4	3	2
26.6	60	17	9	5	4	3	2	2

What about temperature sensing?

- To show lower cost many silo companies exclude temperature sensing in their standard prices. Its very important and absolutely necessary if you you store for periods longer than 2 months. Heat must be detected early and acted upon through aeration. It is recommended that no silo be without thermo detection. Thermo sensing can be installed later but fitting harnesses for the cables from the roof is more difficult then.
- Thermo detection is the one most important aspect that, coupled with aeration and dry-aeration can preserve your grain over extended periods.
- Several options are available from low cost manual systems to advanced systems with weather stations and automatic starting of fans.
- Weather stations are important to avoid heating the grain during aeration or adding moisture during aeration when the inverse is required. Factors like ambient temperature during the entire day and night cycles, relative humidity, air pressure predicting imminent rain, cold and hot spells etc are all vital in deciding when to aerate and when not to aerate.

Temperature sensing

- Simple, manual electronic
  - Inexpensive, number of thermocouples are specified.
  - Can be digital or analogue – prefer digital can be upgraded easier.
  - Hand held instrument and each silo tested manually for hot spots.
  - Can have downloadable software to PC but manually downloaded.
  - Only showing hot spots.
  - Can not remotely start aeration fans.
- Advanced, electronic
  - Remote results – mobile / PC.
  - Can be wireless.
  - Shows bin capacity utilized based on thermocouples.
  - Includes a weather station optionally.
  - Remotely starts aeration fans when programmed for correct conditions.
  - Has good graphics.
  - Can alert you to problems via SMS/email.
  - Can be very expensive for small complexes.

Every bin has a cold and warm side. This results in moisture migrating through the bin with condensation and concentration of moisture in a section of the bin where the grain becomes hot and damaged and which may lead to smoldering eventually.

Heat damaged grain cracks and eventually disintegrates. In the case of wheat, the baking quality is entirely destroyed.

Aeration can also dry grain down somewhat (2-4%) provided ambient humidity is low or is burned off. 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 with an aeration system.

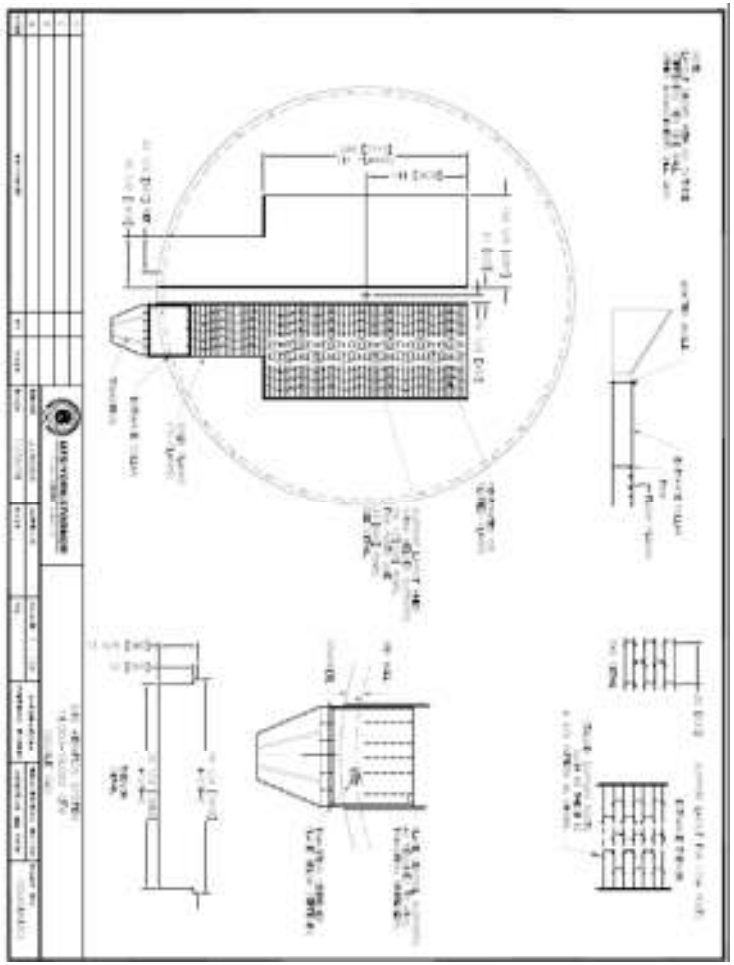
Aeration is recommended for any grain being stored for more than 3 months.

Ensure than your system can be converted to incorporate earation before you buy.

Aeration types

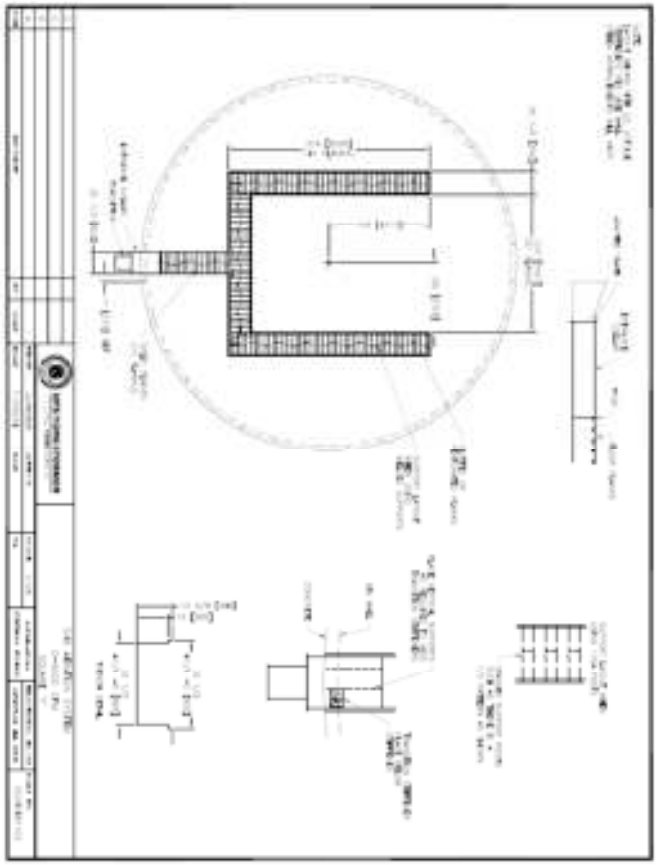
- If a bin is aerated, the correct air volume and pressure should be selected for the type of grain.
- The correct floor and blower will accomplish this.
- Floor types include:
  - Full floor aeration – usually smaller diameter bins and drying bins.
  - Flush floor aeration – channels in various designs in the concrete floor of a silo such as double I; Y; E, square pad etc. A reputable supplier will recommend this.
- Fan selection is determined by pressure and volume air and can either be:
  - Axial fans
  - High or Low speed centrifugal fans

Typical flush floor aeration designs 1



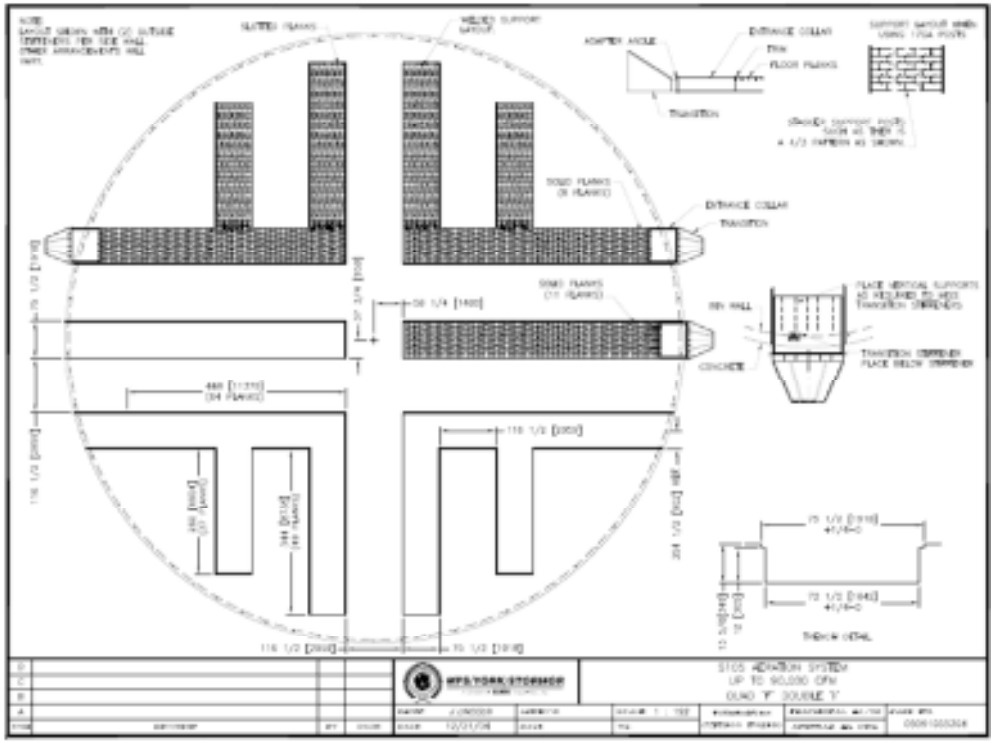
- 48’ diameter silo requiring 14,000 to 18,000 cubic feet per minute air (400 – 511 cubic meter per minute or up to 30,000 cubic feet per hour of air)
- Other designs include double I; Y; centre pad;

Flush floor aeration designs 2



- Y- type aeration for 6,000 cfm (or 170 cubic meter/minute or 10,200 cubic feet air per hour).
- The air volume and required pressure must be accommodated in the design.

Complex aeration designs



- Very complex designs such as this quad F and double I design for 2,556 cubic meter per minute air required in a 105’ (32 meter) diameter silo.

Aeration design parameters

48' Diameter Aeration Systems

Airflow Range	Maximum Ring Height at cfm/bu	Fan Quantity	Entrance Trench Width	Layout Pattern	Flooring Style	Weight	System Part Number
UP TO 6,000 CFM	UP TO 11R @ 1/10,	1	32	SQ 'Y'	FLO 20	1084	05040481102
	7R @ 1/7, 4R @ 1/5				AIR 18	1144	05040481107
		1	52	SQ 'Y'	FLO 20	1323	05040481202
					AIR 18	1396	05040481207
	UP TO 14R @ 1/10,			1 PAD	FLO 20	1448	05010481202
	9R @ 1/7, 6R @ 1/5				AIR 18	1538	05010481207
		2	32	2 "I"	FLO 20	1199	05050481102
					AIR 18	1254	05050481107
UP TO 10,000 CFM		1	52	SQ 'Y'	FLO 18	1926	05040482203
					AIR 16	2122	05040482208
				1 PAD	FLO 18	1647	05010482203
					AIR 16	1792	05010482208
	UP TO 24R @ 1/10,	1	72	SQ 'Y'	FLO 18	2227	05040482303
	16R @ 1/7, 11R @ 1/5				AIR 16	2437	05040482308
				1 PAD	FLO 18	1888	05010482303
					AIR 16	2033	05010482308
		2	52	2 "I"	FLO 18	1946	05050482203
					AIR 16	2102	05050482308
UP TO 14,000 CFM		1	72	SQ 'Y'	FLO 16	3036	05040483303
					AIR 16	2884	05040483308
				1 PAD	FLO 16	2364	05010483303
					AIR 16	2263	05010483308
	UP TO 32R @ 1/10,	2	52	2 PAD	FLO 16	3058	05020483203
	23R @ 1/7, 16R @ 1/5				AIR 16	2925	05020483208
				2 "T"	FLO 16	2797	05090483204
					AIR 16	2674	05090483208
		2	72	2 "I"	FLO 16	3022	05050483304
UP TO 18,000 CFM		2	72	2 PAD	FLO 18	3426	05020484303
					AIR 16	3688	05020484308
				2 "T"	FLO 18	2835	05090484303
	UP TO 32R @ 1/10,				AIR 16	3063	05090484308
	30R @ 1/7, 21 @ 1/5	4	72	4 "I"	FLO 18	4907	05070484303
					AIR 16	5181	05070484308
		2	52	2 'H'	FLO 18	2841	05120484203
					AIR 16	3118	05120484208
UP TO 22,000 CFM		2	72	2 PAD	FLO 16	3914	05020485304
					AIR 16	3716	05020485308
	UP TO 32R @ 1/10,			2 'H'	FLO 16	4418	05120485304
	32R @ 1/7, 22R @ 1/5				AIR 16	4218	05120485308
		4	72	4 "I"	FLO 16	5874	05070485304
					AIR 16	5676	05070485308

NOTES:

1) Use "Aeration Fan Selection" program to determine NECO fan requirements for desired airflow.

2) Select corresponding Aeration System from table above:

a. Use 32" wide trench with these NECO fans: 3/4 - 3 hp axial, 3 - 7 1/2 hp hi-speed 60 Hz cent.

b. Use 52" wide trench with these NECO fans: 5 - 15 hp axial, 5 - 10 hp low-speed 60 Hz cent., 10 - 60 hp hi-speed 60 Hz cent., 3 hp low-speed 50 Hz cent., and 3 - 60 hp hi-speed 50 Hz cent.

c. Use 72" wide trench with these NECO fans: 15 - 40 hp low-speed 60 Hz cent., and 5 - 25 hp low-speed 50 Hz cent.

3) Aeration System from higher cfm ranges may also be selected.

System package includes entrance collar, floor planks, flashing, and floor screws. Package does not include fan or transition. Floor supports and entrance collar stiffeners (if necessary) must also be added to order.

"Flo" style flooring is slotted. "Air" style flooring is perforated.

- The optional flooring layouts, design criteria for airflow in volume air as well as pressure, channel widths, number of vents, type of flooring etc. for each silo diameter.

Aeration parameters

full floor or flush floor (trench) system	flush floor	FAN PARAMETERS:	
diameter (ft)	48	airflow rate (cfm/Bu)	
number of rings (32" sheets)	9	grain depth (ft)	28.28
	1/10	total airflow (cfm)	4113
grain	corn, shelled	Shedd's multiplier	1.5
level or peaked fill	peaked	duct factor (in)	0.5
number of fans (use 1, 2, 4, or 6 with flush floor)	2	a	0.000654
stirring	not stirred	b	0.154432
post style selected	17ga post	floor area (ft^2)	1810
capacity (Bu)	41126	**airflow per fan (cfm)**	**2056**
minimum trench width (in inches) recommended for proper airflow	**32**	**static pressure (in)**	**0.98**

minimum recommended fans:	corresponding transition part number to use with this fan:	corresponding flush floor trench size required with this fan:	quantity of roof vents (P/N 058010) to use with this fan: (for max cfm's)
NECO 1 hp axial fan	**N040759**	**32 inch wide**	**5**
NECO 5 hp low-speed centrifugal 60Hz fan	**N043324**	**52 inch wide**	**8**
NECO 3 hp high-speed centrifugal 60Hz fan	**N040765**	**32 inch wide**	**4**
NECO 7 1/2 hp low-speed centrifugal 50Hz fan	**N043326**	**72 inch wide**	**11**
NECO 3 hp high-speed centrifugal 50Hz fan	**N043324**	**52 inch wide**	**4**

selected fan:	**N043324**	**52 inch wide**	**4**
NECO 3 hp high-speed centrifugal 50Hz fan	**fan OK for desired airflow rate**		

- Typical aeration parameters for a 48’ 9 ring silo with 1cfm air/10 bushels with 2 fans, peaked shelled maize, unstirred grain

Should you be drying grain?

- If in a mist belt, you may loose months before being able to harvest and drying may pay for itself rather quickly.
- Some areas have pests like ants, mandating early wet harvest.
- You can harvest at 26% moisture and obtain higher yield and hectoliter mass.

Drying parameters

output

NECO GRAIN DRYER SIMULATOR

DRYER SPECIFICATIONS

Dryer Length	=	24ft
Number of Tiers	=	6
Holding Capacity	=	1155 bu (24.8 MT) (including the garner)
Number of Blowers	=	2
Blower 1 CFM (top)	=	27500 CFM (778.717 m^3/min)
Blower 2 CFM	=	27500 CFM (778.717 m^3/min)

OPERATING CONDITIONS

Crop	=	Corn
Initial Moisture	=	20% w.b.
Final Moisture	=	14% w.b.
Burner 1 Temp (top)	=	210 deg F (98.8889 deg C)
Burner 2 Temp	=	210 deg F (98.8889 deg C)
No. Cooling Tiers	=	2
Initial Grain Temp.	=	122 deg F (50 deg C)
Outside Air Temp.	=	122 deg F (50 deg C)
Outside Air Hum.	=	40%

High Temp
Low Humidity

PERFORMANCE

Drying Capacity	=	522 bph (11.2 MT/hr)
Total Burner Output	=	2.98M BTU/hr (872.238 kW)
Total Fan Output	=	55000 CFM (1557.43 m^3/min)
Average CFM per bu	=	63.5726
lb water Removed per bu	=	8.92269
lb water Removed per hr	=	4659.88
BTU per bushel	=	5700.18
BTU per lb water Removed	=	638.841
Liquid Propane Usage	=	32.5347 gal/hr, 0.0622971 gal/bu
Natural Gas Usage	=	2976.92 ft^3/hr, 5.70018 ft^3/bu
Maximum Grain Temperature	=	142.194 deg F (61.2187 deg C)
Outlet Grain Temperature	=	104.763 deg F (40.4239 deg C)

- Drying Simulators giving output for drying criteria based on:
  - Type of grain
  - Ambient temperature
  - Ambient humidity
  - Drying heat
  - Initial moisture

Drying parameters (2)

output

NECO GRAIN DRYER SIMULATOR

DRYER SPECIFICATIONS

Dryer Length = 24ft
Number of Tiers = 6
Holding Capacity = 1155 bu (24.8 MT) (including the garner)

Number of Blowers = 2
Blower 1 CPM (top) = 27500 CFM (778.717 m^3/min)
Blower 2 CPM = 27500 CFM (778.717 m^3/min)

OPERATING CONDITIONS

Crop = Corn
Initial Moisture = 26% w.b.
Final Moisture = 14% w.b.

Burner 1 Temp (top) = 210 deg F (98.8889 deg C)
Burner 2 Temp = 210 deg F (98.8889 deg C)
No. Cooling Tiers = 2

Initial Grain Temp. = 41 deg F (5 deg C)
Outside Air Temp. = 41 deg F (5 deg C)
Outside Air Hum. = 40%

Low Temp
Low Humidity

PERFORMANCE

Drying Capacity = 465 bph (10 MT/hr)
Total Burner Output = 7.07M BTU/hr (2072.17 kW)
Total Fan Output = 55000 CFM (1557.43 m^3/min)
Average CFM per bu = 63.3726

lb Water Removed per bu = 8.92269
lb Water Removed per hr = 4147.01

BTU per bushel = 15216.6
BTU per lb water Removed = 1705.39

Liquid Propane Usage = 77.2924 gal/hr, 0.166302 gal/bu
Natural Gas Usage = 7072.26 ft^3/hr, 15.2166 ft^3/bu

Maximum Grain Temperature = 129.492 deg F (54.1621 deg C)
Outlet Grain Temperature = 44.9805 deg F (7.21139 deg C)

- Typical drying requirements for low temperature, low humidity application for the same product as before. +-3,400BTU’s/kW)
- Capacity more than 10% higher with higher ambient temperature

Types of drying systems

- High temperature self-contained dryers
  - Manual batch dryers
  - Automatic batch dryers
  - Continuous flow dryers
- In-Bin drying – Top dryers – Roof bin batch
- In-bin drying – on-floor batch
- In-bin drying – continuous flow
- In-bin drying – batch with Stirring machines
- Low temperature in-bin drying – solar & other energy options.
- Dry-aeration

Energy sources and burners

- Electricity – expensive and high infra-structural cost, clean.
- Gas – depends on availability – high infra-structural costs , clean.
- Diesel and light / heavy industrial oil/ bio-diesel- available, usually least expensive and little infra-structural cost, dirty, requires heat exchanger which increases outlay cost.
- Coal – least expensive, dirty environment, requires heat exchanger.
- Biomass- much work to be done on utilizing farm waste, briquettes, pellets etc. and probably the way to go forward. Wood commonly used in Brazil. Requires heat exchanger.
- Other sources– mainly used in dry-aeration includes wind power, solar power where conditions are favorable. Low intensity heat usually provided and long drying times.

Should grain be cleaned before storage?

- With high quality harvesters grain is often received well cleaned. If in doubt however, it is recommended that fines at least be removed prior to storage.
- Why?
  - It concentrates in the centre of the silo, thereby risking downgrading of grain when sold.
  - It also hampers drying and aeration as it creates dense pockets.
  - It uses unnecessary storage space and drying capacity you have paid for.
  - It can contain harmful & poisonous seeds.

What Pre-cleaner should be selected?

- Cleaning is normally done at intake but may also be installed at unload.
- The cleaning capacity is determined by the intake capacity.
- Normally rotary cleaners can handle around 40 – 60 tons per hour. If intake capacity is larger two or more may be required. Rotary cleaners can sometimes separate both unders and overs but often only unders.
- Eccentric / vibratory high capacity cleaners can handle very high capacities and screens unders and overs out. Pre-cleaning capacity vs. final commercial cleaning can vary as much as 150tph pre-cleaning to only 50 tons final cleaning
- Aspiration can be used at higher capacities. This separates only the fines however and may be used in conjunction with grading separators.
- Zig Zag gravity cleaners can be installed on a downward leg, normally at loading of trucks or unload into a mill etc. This would also separate fines only.

What are the intake options? (1)

- **Screw conveyors** – when bins are not too high or volume is not too big and speed is limited to 40 – 80 tons per hour:
  - In a fixed installation – one intake, split, roof augers
  - As mobile auger – one auger for all bins for loading and unloading into trucks again. Often the cheapest option.
  - Augers can transfer between silos.
  - High RPM damages grain. Usually the least expensive option for smaller and few silos.

Auger capacities

Auger capacities and power consumption

Dia mm	RPM	Kg/Hr @ 35 Deg	KW/3m	Kg/Hr @ 45 deg	kW/3m
100	600	8,000	0.675	7,500	0.75
165	600	37,500	1.2	29750	1.2
219	450	47,250	1.65	45000	1.725
276	360	70,000	2.4	65500	2.4
325	300	96,750	3	89750	3
350	260	133,500	4.05	114750	4.125
400	225	170,000	5.25	160000	5.3

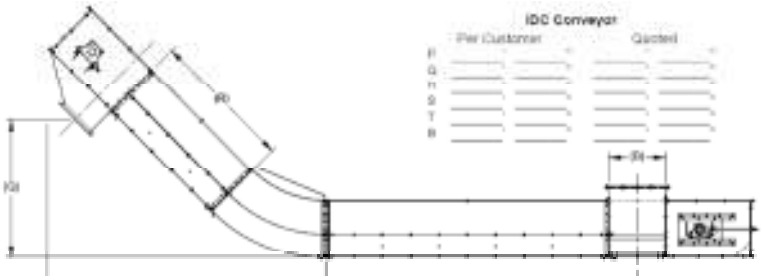
What are the intake options? (2)

- **Bucket elevator**:
  - An old time favourite – can be fast, reliable, low power.
  - Requires a high structure to allow the correct gravitational angles or in combination with a chain conveyor to one or more silos, rather costly.
  - High wear and tear on down pipes.
  - High broken kernel losses due to high speed down flow if not checked.
  - Relatively expensive.
  - Requires additional foundation costs.

What are the intake options?(3)

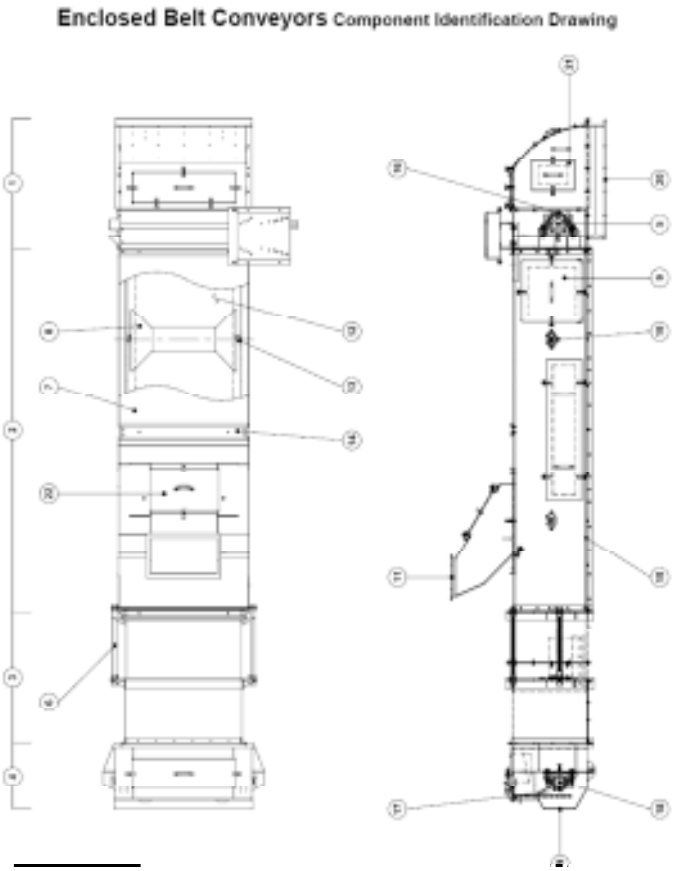
- **Air transport:**
  - Usually more expensive than augers and less than bucket elevators.
  - No infrastructure required.
  - Can be used to load & unload trailers & trucks in the field also – versatile.
  - One system can load and unload many silos.
  - High power consumption but can be tractor driven – then relatively cheap.
  - High wear & tear on pipe corners if not stainless steel.

Chain conveyors



- Drag conveyors uses for high capacity mostly horizontal conveying but can be applied to some vertical and horizontal conveyance. Exceptional for loading cleaners for instance and transferring grain over long distances.

Belt conveyors



- High capacity 250 tons per hour.
- Long distances.
- Gentle action on product.
- Reliable and relatively low maintenance.
- Difficult flowing product.

What are the intake options?(4)

- **Grain Pump**
- The preferred way to load and unload silos especially of 2 or more silos per complex..
- The system is in the form of a tubular loop in which a chain and discs revolve to transport grain both on intake and unload legs:
- Fast and easy, with minimal breakages, low maintenance, low wear, high capacity (from 40tph – 450 tph), flexible & over long distance, low power consumption, cost effective, minimal electric motors & switchgear, easily expandable, virtually no civil works, eliminates need for unload augers etc..
- More expensive for use in one silo but well in line when used in systems with two or more silos.
- Can be used a double loop for angled conveyance also.
- Can be used for simultaneous intake and unload.

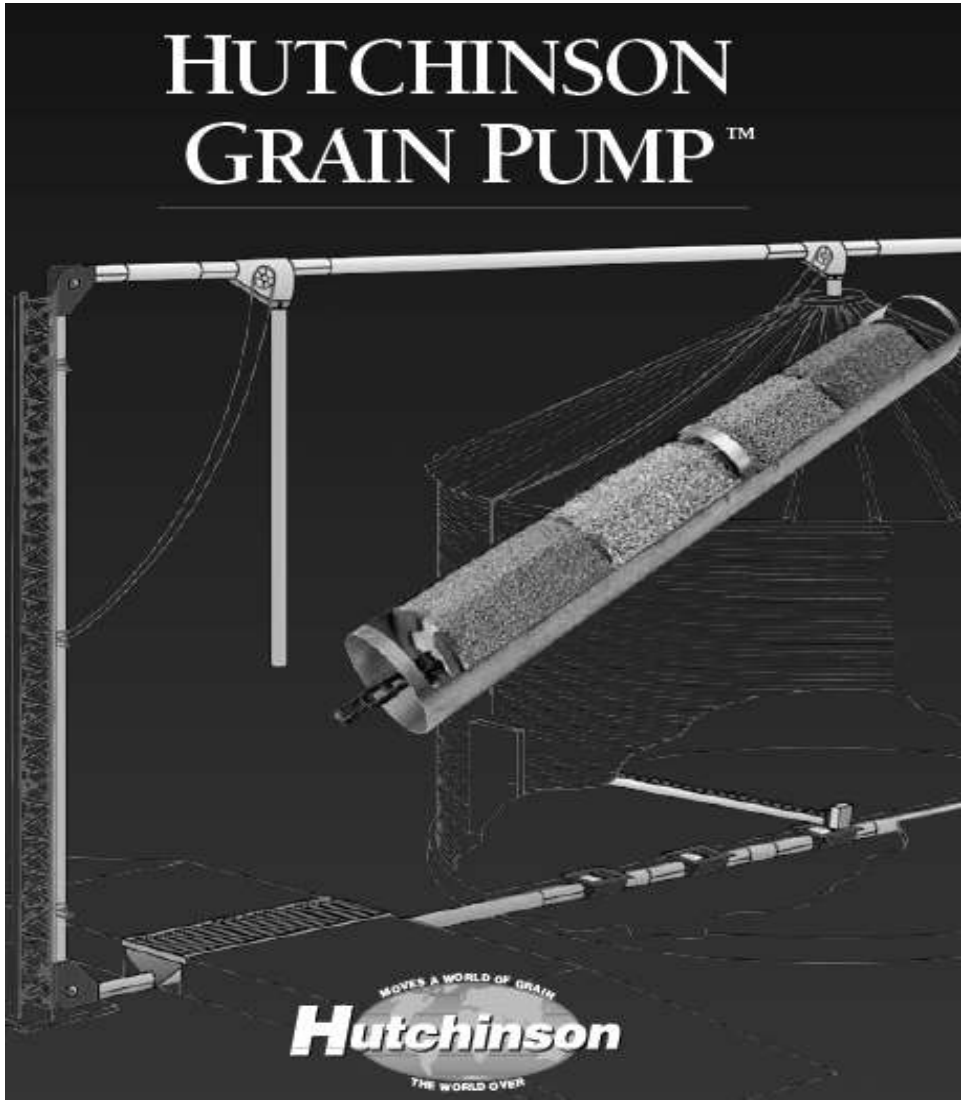
Grain loops

- A large silo complex using grain loops only.

What are the most common unload options?

- **Auger unload** systems are most common. In various capacities from 100mm – 300mm or 5 tph – 150 tph.
- Beyond these capacities, **chain conveyors** are used. May also be used for lower capacities and preferred to down tubes where bucket elevators are used.
- **Belt conveyors** especially where sensitive products are handled, high capacity and long distance.
- The **Grain Pump** combines all the advantages and none of the disadvantages.

HUTCHINSON GRAIN PUMP™



Sweep Augers

- A sweep auger is used to gather the last remaining grain in a flat bottom silo after it has stopped flowing, to the center of the bin for unloading. Several options are available:
  - Standard sweep – carried into the silo via the door (insist on 2 ring doors as access is just so much easier) when the grain level permits. A lighter duty sweep for bins not in excess of 36’ diameter.
  - Commercial sweep – as the standard but heavier duty often used in larger bin of 42’ – 54’
  - Power sweep – drive is outside and engaged from outside the bin. Sweep stays inside the bin even when full of grain. The price normally includes the unload auger and used in bins of all diameters.
  - Tractor sweep – as for the power sweep but for very heavy duty for 75’ – 105’ diameter bins.
  - Sometimes the door opening is large enough to accommodate a Bobcat to bring remaining grain to the center for unload – used in very large 90’ and 105’ diameter bins.

Silo foundation options (1)

- 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.

Silo foundation options (2)

- Why would you consider a conical below ground level floor?
  - Additional storage is gained but at high cost.
  - One transport auger less can be used for small installations.
  - No sweep auger is required.
  - For short term storage not requiring aeration

Conical above ground foundations

- This is preferred by many silo operators due to:
  - Easier unload through gravity. No reliance on equipment that may be under grain.
  - Used especially in large concrete silo complexes.
  - Allows for reclamation tunnels still above ground level.
  - Aeration can be done properly.
  - Usually airtight silos.
  - Expensive option.

Silo Foundations (3)

- Soil stability dictates the silo foundation requirements and civil works. First step is a proper soil analysis.
- Soil stability at 96 Kpa and 190 Kpa would have a large impact on civils. The engineer should decide to what level and with what measures the soil conditions should be improved.
- This may be excavation and backfilling, concrete filling, bigger foundation footprint, more re-bar or a combination of the above.

Site selection 1

- Make sure your site is:
  - As level as possible – earthworks are expensive
  - Not too near your home – dust and noise can be excessive.
  - Secure – many tons can be stolen from silos before you notice. Damage to grain and equipment may also result.
  - Surface water – ensure your silo can not be flooded and is elevated high enough with good drainage and above flood levels.
  - Soil stability
  - Is there enough space for expansion? Truck movement? Trailer movement?
  - Is the site accessible from main roads? Are roads reliable?
  - Electrical power can be expensive to move far.

Foundation Notes:

1. The foundation site should be well drained and free of vegetation and/or debris.

2. Foundation(s) should be on undisturbed soil or engineered compacted backfill.

3. A soil and foundation (Geotechnical) investigation should be conducted for each site to confirm the soil bearing capacity.

4. Foundation Design is based on the specified allowable soil bearing capacity.

5. The concrete shall have a minimum compressive strength of 3,000 psi. at 28 days.

6. Concrete should be allowed to cure 7 days before beginning the tank assembly and 28 days before filling the bin.

7. Concrete should be kept level to ±1/8" in 10' and 1/2" across the diameter. High spots or debris should be removed prior to setting the bin.

8. Anchor bolts need to be properly located based on information provided in order to keep the tank round, and to ensure structural integrity of the bin while guaranteeing effective transfer of wall forces down to the foundation. The minimum cast-in-place anchors for standard conditions shall be A307 9" x 3" hooked bolts of the required diameter: 3/4" for commercial flat-bottomed bins (1" required for 60' and larger bins with a sidedraw) and commercial hopper tanks; 5/8" for unstiffened grain bins, and 1/2" for unstiffened hopper bins. Hook of bolt must be placed below the horizontal rebar for proper transfer of forces. Alternately, hex-head bolts with flat washers or an epoxy adhesive anchor of equivalent strength may be used. Check with the epoxy anchor vendor or manufacturer for strength ratings and for proper installation instructions.

9. All reinforcing rod for concrete reinforcement shall conform to ASTM A615, Grade 60.

10. Rebar should lap a distance equal to [Rebar Dia. x 24]. Minimum allowable lap is 18" - i.e: #6 Rebar has a diameter of 6/8": 024 x .75" = 18", or an 18" lap.

11. Estimates for Rebar do NOT include allowances for the lap.

12. The stiffener and sidewall must be supported over tunnels.

13. Concrete yardage figures do NOT include any allowances for aeration trenches or tunnels.

14. Ring reinforcement must be continuous around the tunnels.

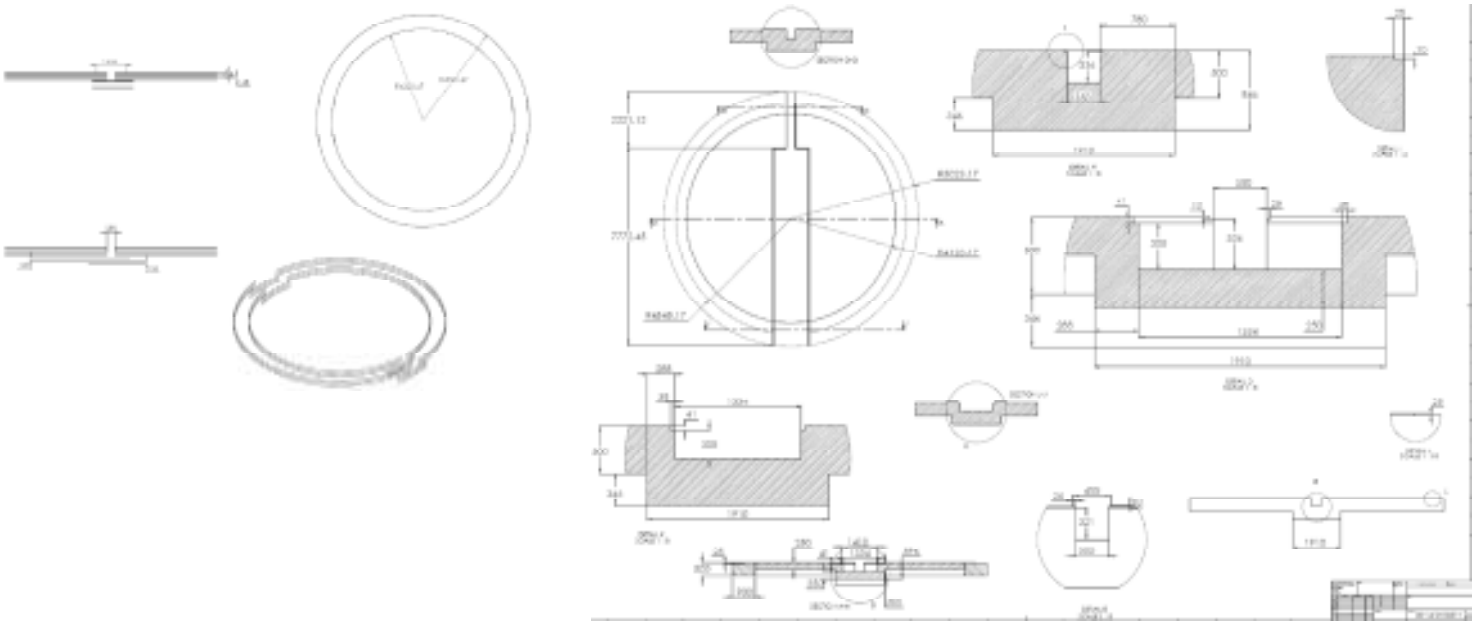
15. To help minimize potential frost heave, the bottom of the footings should be at or below the frost line. Alternately, the footings could be supported on non-expansive fill materials (such as crushed stone or gravel) which are not susceptible to frost heave, extending below the frost line; however, some local building codes do require the footing to extend below the frost line.

16. Foundation details in this manual are to be considered general in nature and are intended only as a guide. This design is for standard external loading conditions: 90 mph wind speeds and seismic zone 0 earthquake loads. It is the owner's responsibility to provide an appropriate site and foundation design for the adequate support of the grain bin. MFS/YORK/STORMOR assumes no responsibility for results arising from these suggestions. Check with the MFS engineering department for contact information on foundation design and soil testing professionals.

Site Selection 2

- Arrangement and layout. Consider the following:
  - Grain handling & cleaning equipment
  - Wet holding, drying, cooling, storage bins
  - Dryer – if not in-bin
  - Weighbridge & office.
  - Management building
  - Feed processing and storage
  - Electrical service, roads.
  - Turning circles of various trucks

Typical foundation design drawings



Foundations (4)

- Obtain drawings for the specific silo foundation and be sure to understand this or get help.
- Soil should be properly stabilized and compacted and dug to correct depth.
- Sufficient re-bar should be used as specified.
- Correct cement mix at 25MPA should be used. If lower grade cement is used, the mix should be adjusted. 19mm stone should be used.
- The ring beam carries most pressure.
- All cement casting should be done continuously.
- Correct levels should be found.
- The bin may be fixed to the foundation with chemical bolts or with the foundation rebar.

Silo selection (1)

- What quality silo am I offered? How is this evaluated? Easy, inspect and research:
  - Workmanship by appraising other similar installations,
  - Galvanizing is 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,
  - Corrugation length (the longer the corrugation the less the profile, thus the strength and amount of steel used (compare a 4” vs. a 2.66” corrugation)

Silo selection (2)

- 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. Avoid companies working out of a post office box and email only.
- 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. The alarm bells should ring if the silo is too cheap. It's a project that should serve you for 30 years, buy on quality and peace of mind, not on cost.
- Select companies with its own workshop who can react to emergencies by manufacturing a part if required.

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.
  - What is included? Inside & outside ladders? Eave platform? Spiral staircase? Rest platforms? Special OSHA certified ladders & platforms? Roof ladders?All these items cost money but may improve convenience, safety etc.
  - Capability to side draw on a silo for instance offers lower unload costs for up to +-60% of the silo but the silo must be designed for that with stronger sidewalls. This means grain can be directly discharged from the sidewall into a truck until the grain will no longer flow.

Ordering silos

- Obtain at least 2-3 quotations from reputable suppliers
- Ask for and follow up on at least 1 genuine referral provided by the supplier.
- Plan well in advance. If you intend putting up your own storage, allocate at least 4-6 months for the project. Do not buy from a supplier simply because he has stock at the moment.
- Ensure you order the right model and quality silo as agreed to. Recheck the capacity in cubic meter and convert to tons at 0.75 for maize and 0.80 for wheat. “High Compaction rates” may be used by some dealers to inflate silo capacity.So are conical floors.
- Compare different silo weight from suppliers.
- Compare roof carrying capacity.
- Compare steel tensile and galvanizing.
- Be prepared to pay a +-30% deposit and to issue a bank guarantee for the remainder, payable on delivery. Obtain a proper contract and/or tax invoice. Most banks will finance silos in their Asset Finance Divisions.
- Ensure you have read and understand the fine print and exclusions. Often foundations are quoted but it excludes sand, cement, bricks and stone. What exactly are included then?

Do you pay for manual labourers? How many would be needed? Do you pay for accommodation and subsistence? For how many and how long? Is crane costs included? If not what crane and how long would rental be? Should you provide power and services such as toilets and showers on site and do you have that available? Who will offload the trucks? Do you get operations and installations manuals? Is there assistance with start-up? Is it needed / charged? Is your price delivered on site or ex factory USA / CIF Port / are any charges such as clearing excluded?

More information

- It has been attempted to touch briefly on the major aspects you should consider when starting your own grain storage complex.
- Obtain more information by ordering:
- “THE GRAIN DRYING, HANDLING AND STORAGE HANDBOOK” at a price of R250 + VAT for South African buyers by contacting us at the detail below or by visiting www.abchansenafrica.co.za

The ABC Africa Group

- The ABC Africa group consists of associated companies manufacturing and/or supplying as authorized agents within the African market mainly, the following main types of agro equipment:
  - Grain Storage, Handling, Cleaning & Drying Equipment
  - Grain milling equipment and mill consumables, including roller fluting and stone dressing services.
  - Oil seed Expelling & Soya bean Processing
  - Feed mills
  - Weighbridges, livestock scales & tipscales

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