PHILIPPINE NATIONAL STANDARD

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ICS 65.040.20

Agricultural Infrastructures – Silo

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Foreword

The Philippine National Standard (PNS) for Agricultural Infrastructures – Silo (PNS/BAFS PABES ___:2019) has been prepared by the Technical Working Group (TWG) for Silo and Corn Mill as per approved Department of Agriculture Special Order (SO) No. 238 Series of 2017 and SO No. 554 Series of 2018.

This Standard has been technically prepared in accordance with International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) Directives Part 2, 8th edition – Principles and rules for the structure and drafting of ISO and IEC documents.

The word “shall” is used to indicate mandatory requirements to conform to the standard.

The word “should” is used to indicate that among several possibilities one is recommended as particularly suitable without mentioning or excluding others.

1 Scope

This standard specifies the requirements for construction, equipment, and accessories of steel silos used for grain storage.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASAE S413.1:1997, *Procedure for Establishing Volumetric Capacity of Cylindrical Grain Bins*

NSCP Volume 1, Section 208, *National Structural Code of the Philippines Buildings, Towers, and Other Vertical Structures - Earthquake Loads*

Philippine Electrical Code

Fire Code of the Philippines

OSHS Rule 1067, *Fixed Ladders*

ASAE S412.1:1997, *Ladders, Cages, Walkways, and Stairs*

3 Terms and Definitions

For the purpose of this standard, the following terms shall apply.

3.1
aeration
movement of air through stored grains for purposes other than drying

3.2
access door
provides access inside the silo which may be located at the roof or at the wall

3.3
angle of friction
angle of the material when the grains held starts to move

3.4
base flooring
floor located at the basement of flat bottom silos

3.5
control panel
panel where all the controls are located, with or without mimic board

3.6
eave height
height of the vertical-walled segment of silo

3.7
elevator
mechanism that facilitates vertical movement of grains

3.8
elevator boot
equipment for receiving grains at the bottom of a bucket elevator

3.9
equivalent height
height of grains at level condition

3.10
fumigation
action of releasing a toxic chemical in the gaseous state to control a targeted pest

3.11
grain
milled or unmilled, seeds or fruits of various food plants more specifically the cereal grasses.

3.12
headhouse
dumping house
intake house
grain receiving area which may consist of elevator and other accessories such as weighing and cleaning machines.

3.13
hopper
sloping, walled structure for discharging grains

3.14
load distribution system
structure above the silo bins that houses conveyor systems for grain distribution

3.15
mimic board
board where the flow of grains at different points of the system at any time will be reflected

3.16
overall height
distance between the horizontal supporting plane surface and the horizontal plane touching the uppermost part of the silo structure

3.17
overall length
distance between the vertical planes at the right angles to the median plane of the silo structure and touching its front and rear extremities

3.18
overall width
distance between the vertical planes parallel to the median plane of the machine, each plane touching the outermost point of the silo structure on its respective side

3.19
peak height
overall height of the silo structure from the topmost structure of the roof to the ground

3.20
silo
unit consisting of upright containers used for storage and handling of grains in bulk and provided with necessary equipment and accessories

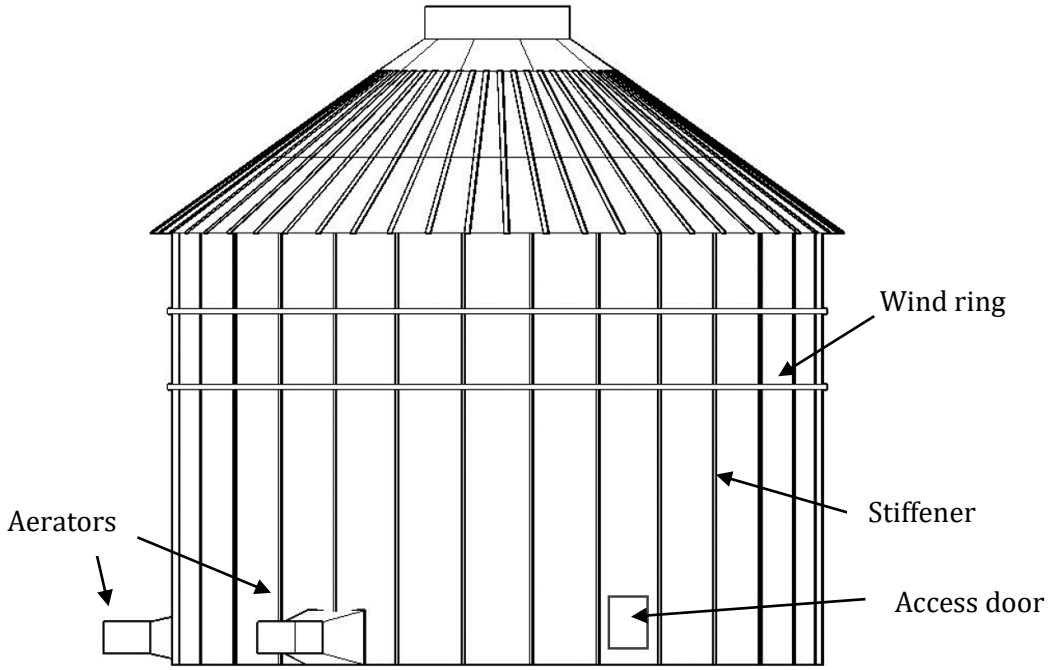

Figure 1 — Flat bottom silo with its basic components

3.21
silo diameter
inside diameter of the largest inscribed circle within the silo cross-section

3.22
silo flooring
surface at the bottom of the silo where the grains lie

3.23
slenderness
aspect ratio
ratio of the equivalent height (h) to the silo diameter (d), (h:d)

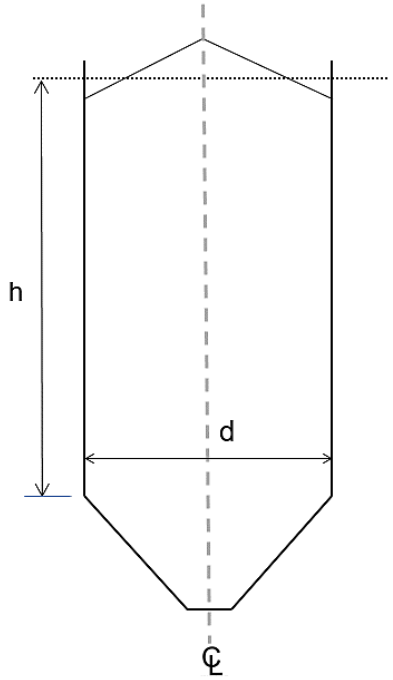

Figure 2 – Equivalent height and silo diameter in a silo with hopper bottom

3.24
spout
passageway of grains to be loaded into the silo

3.25
stiffener
vertical frame fastened to the silo walls which carries the loads

3.26
storage block
portion of the silo where grains are stored

3.27
transition
intersection of the hopper and the vertical wall, for hopper bottom type silos

3.28
unloading system
structure below or at ground level that houses the collection equipment

3.29
volumetric capacity
volume contained in the cylindrical portion only of the silo or the volume contained in both the cylindrical portion and the conical section within the roof space

3.30
wall ring
one level of the storage block of silo

3.31
weather proofing
process of sealing the connections between sheets and other parts such as caulking

3.32
wind rings
connected to the sidewall stiffeners to provide continuous circular reinforcement around the silo

4 Classification

The classification of silos should be according to the following:

4.1 Slenderness

4.1.1 Retaining

A silo that has an aspect ratio less than or equal to 0.4 ($h/d \leq 0.4$) with a flat bottom

4.1.2 Squat

A silo that has an aspect ratio greater than 0.4 and less than or equal to 1 ($0.4 < h/d \leq 1.0$). If the silo has an aspect ratio less than or equal to 0.4 ($h/d \leq 0.4$) and has a hopper, it is also classified as squat.

4.1.3 Intermediate

A silo that has an aspect ratio greater than 1.0 and less than 2.0. ($1.0 < h/d < 2.0$)

4.1.4 Slender

A silo that has an aspect ratio greater than or equal to 2.0 ($h/d \geq 2.0$)

4.2 Other Classifications

Silos may also be classified according but not limited to the following:

Wall Material	Corrugated Plain
Discharge Mechanism	Mechanical Gravitational
Silo Bottom	Flat bottom Hopper bottom
Control	Manual Automatic
Cross-section	Round Square Rectangular

5 Location

5.1 The site should be dry and the structure shall be elevated to avoid water logging and to be safe from natural flooding calamities. If the area is water logged, the structure shall be elevated higher than the anticipated maximum flood level.

5.2 The structure, as far as possible, should be well away from source of contamination, such as slaughterhouse, tanneries, and residential areas.

5.3 It shall be free from fire hazards.

5.4 The structure shall be built on a stable solid ground.

5.5 Road access, electricity, communication, water services, and drainage should all be available.

5.6 The seismic conditions of the area shall be given consideration such that the structure will not lie on fault lines.

6 Estimation of volumetric capacity

The volumetric capacity of the silo shall be determined using the method stated in the ASAE S413.1:1997.

7 Construction and Structural Requirements

7.1 General

7.1.1 All metal materials for construction shall be corrosion resistant.

7.1.2 All silo parts shall be hot-dipped galvanized.

7.1.3 All parts in contact with the grains shall not be painted.

7.1.4 The structure shall have means to prevent entry of birds, rodents, and other pests.

7.1.5 The silo shall be able to withstand the maximum wind speed observed in the area.

7.1.6 The minimum design earthquake load shall be according to Section 8 Earthquake Loads of the National Structural Code of the Philippines (NSCP).

7.1.7 All electrical connections shall conform to the Philippine Electrical Code.

7.2 Foundation

7.2.1 The foundation shall be rigid enough to carry the designed load.

7.2.2 The type of foundation shall be decided taking into account the layout, nature of soil, and the loads transferred.

7.2.3 The construction of foundation shall be in accordance with the NSCP.

7.3 Flooring

The floor shall be configured in such a way that the minimum aeration requirement will be achieved.

7.3.1 Base flooring

7.3.1.1 It shall be made of reinforced waterproofed concrete.

7.3.1.2 Side walls in the basement shall also be waterproofed.

7.3.2 Silo flooring

7.3.2.1 Flat bottom

The net area of perforations shall be at least 15 percent of the gross floor area. The perforations may be round or slatted.

7.3.2.2 Hopper bottom

The slope shall be designed to be suitable for easy gravity flow of the intended grains to be stored. Angle of the sloping sides shall be at least 10 degrees greater than the grain’s angle of friction.

7.4 Wall

7.4.1 Wall material shall be corrosion resistant and shall not be painted.

7.4.2 Rivets or bolts and nuts shall be used to join wall materials. Wall materials shall not be welded.

7.4.3 Weather proofing shall be done to prevent leaks.

7.4.4 Walls shall be constructed with access door for flat bottom silos.

7.4.5 The overlapping parts of the wall sheets shall not coincide with those of the adjacent levels.

7.4.6 Walls should be installed with stiffeners.

7.4.7 Ladders shall be installed inside and outside of the wall.

7.5 Roof

7.5.1 The roof shall be leak proof.

7.5.2 The slope of the roof shall be suitable for proper drainage of rain water.

7.5.3 Openings intended for aeration, grain inlet, etc. located at the roof shall be designed to prevent water leakage.

7.5.4 Roof shall be constructed with access door.

7.6 Safety Requirements

7.6.1 There should be a provision for fire control equipment as provided in the Fire Code of the Philippines.

7.6.2 The ladder shall conform to the requirements of OSHS Rule 1067 and ASAE S412.1:1997.

7.6.3 An alarm shall be installed which will be actuated in case of malfunctions. An emergency stop button shall be provided.

7.6.4 Safety decals shall be set up in conspicuous areas.

8 Equipment and Accessories

8.1 Conveyors

8.1.1 Classification

The classification of conveyors should be according to the following:

8.1.1.1 Belt

Belt conveyors consist of a flat continuous belt in tension that is positioned between rollers driven by pulleys with intermittently spaced idlers for support.

8.1.1.2 Screw

A screw conveyor is made up of a continuous helix that is mounted on a pipe in a fixed trough. Movement of the material is facilitated by the rotation of the screw. The conveyor may have multiple feed points as long as the designed allowable loading is not exceeded. The conveyor may also have multiple discharge points.

8.1.1.3 Chain

Chain conveyors consist of a continuous loop of chains between two sprockets. A take-up device which is connected to the sprocket opposite to the drive sprocket is responsible for proper tensioning of the chain. The materials are conveyed using some type of attachment such as pans.

8.1.1.4 Pneumatic

Pneumatic conveyors use high pressure air to transport grains in a totally enclosed system. It consists of the high pressure air source, a feed device, a conveying pipeline, and a receptacle for release of transported material and carrier gas.

8.1.1.5 Bucket Elevator

Bucket elevators are ideally used for the vertical conveyance of loose grains. It consists of several buckets that are carried by either belt or chain elevators.

8.1.2 Construction Requirements

8.1.2.1 The applicable types of conveyors to be used for different conditions are summarized in Annex A.

8.1.2.2 Conveyor casings and connecting spouts shall be dust tight.

8.1.2.3 The buckets of the bucket elevator shall be constructed with non-metal materials.

8.1.2.3 For elevator boots above floor level, adequate clean-out doors shall be provided. On the other hand, for pit-type, enough space shall be provided for cleaning, oiling, and repairing the boots. The area shall also be provided with fixed lighting and shall be accessible by fixed permanent metal ladder or stairway.

8.1.2.4 The boots shall be constructed to minimize the probability of clogging. It shall be provided with covered hoppers into which spilled grains may be loaded again into the boot.

8.1.2.5 Conveyors shall be provided with catwalks. Bucket elevators shall be provided with service platforms. If bucket elevator is more than 6m, a support tower shall be provided.

8.1.2.7 There should be provisions for magnets to ensure that the grains are free of metallic objects.

8.1.2.6 For flat bottom silos, a sweep auger should be installed.

8.2 Control Panel

8.2.1 The control panel shall be illuminated.

8.2.2 It should be provided with a mimic board.

8.2.3 If the control panel is located in a room, the room shall be well-ventilated and dustproof.

8.2.4 Control panels shall be weatherproof, if not installed in a control room.

8.2.5 There shall be provisions for circuit breaker, magnetic starter, and overload device, as provided by the Philippine Electrical Code.

8.3 Temperature and Relative Humidity (RH) Measurement

8.3.1 The temperature and RH throughout the silo shall be measured using calibrated temp and RH sensors, placed at different locations inside the silo.

8.3.2 The sensors shall be connected to reading instruments located outside the silo. If connected using cables, sensors shall be insulated using materials that are resistant to abrasions, moisture, and chemicals.

8.3.3 There shall be at least one temperature and RH sensor to measure the ambient temperature.

8.4 Grain Moisture Content Measurement

Built-in moisture meters should be provided. If moisture meters are not built in, a calibrated portable moisture meter shall be provided.

8.5 Aeration Equipment

8.5.1 The system shall be able to prevent increase in temperature and development of hot spots on grains.

8.5.2 A manometer should be installed inside the silo and plenum.

8.5.3 Roof vents shall be installed for exhaust of air.

8.6 Fumigation Equipment

8.6.1 Fumigator for the application of the liquid or gas fumigants should be incorporated.

8.6.2 Accessories required in this operation shall be made of corrosion resistant materials.

8.7 Other Equipment and Accessories

8.7.1 Grain spreaders should be installed in the loading system.

8.7.2 There should be a provision for dust collection in the headhouse.

9 Warranty, Operation, and Maintenance

9.1 Warranty shall be provided for parts and services except for normal wear and tear of expendable or consumable maintenance parts for at least one (1) year upon the acceptance of procuring entity of the silo.

9.2 An operator's manual shall be provided.

9.3 Training on operation and maintenance shall also be provided.

9.4 A list of warrantable parts shall be provided.

ANNEX A
(informative)

Recommended applications of different conveyors

Type	Horizontal Conveying	Vertical Conveying	Inclined Conveying	Distance to be conveyed	Handling Capacity
Belt	Yes	No	Up to 15°	Long distances	High
Screw	Yes	No	Any inclination but with inverse relationship with capacity	Up to 40 meters	Low
Chain	Yes	No	Yes	Up to 30 meters	High
Pneumatic	Yes	Yes	Yes	Up to 50 meters	High
Bucket elevator	No	Yes	Yes	--	High

Source: IS 5503-2:1969 General requirements for silos for grain storage: Part 2 Grain handling equipment and accessories

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