

Foreword

The formulation of this national standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled “Enhancing the Implementation of the AFMA Through Improved Agricultural Engineering Standards” which was funded by the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA).

This standard has been technically prepared in accordance with PNS 01-4:1998 (ISO/IEC Directives Part 3:1997 – Rules for the Structure and Drafting of International Standards. It specifies the general requirements for the construction of fruit and vegetable storage.

The word “shall” is used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted.

The word “should” is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

In the preparation of this standard, the following references were considered:

CIGR Handbook of Agricultural Engineering. American Society of Agricultural Engineers. United States of America, 1999.

Fellows, P., Guidelines for Small Scale Fruit and Vegetable Processors. FAO Agricultural Services Bulletin-127. Rome, 1997.

Handle Your Produce Better from Harvest to Retail. ASEAN-PHTRC Extension Bulletin No. 2, 1983.

Henderson, S. and R. Perry, Agricultural Process Engineering, 3rd Edition. AVI Publishing Co. Westport, Connecticut, 1976.

Layout and Design of Refrigerated Storages. Farm Structures. Agdex: 736, October 1989.

Paltrinieri, G., F. Figuerola and L. Rojas, Technical Manual on Small-Scale Processing of Fruits and Vegetables. FAO Chile, 1997.

Agricultural Structures – Fruit and Vegetable Storage

1 Scope

This standard specifies the minimum requirements of fruit and vegetable storage. It includes general, structural and functional requirements. Storage can be either free standing or built into an existing structure. This standard does not cover the controlled atmosphere storage.

2 Reference

The following normative document contains provisions which through reference in this text constitute provisions of this National Standard:

National Building Code of the Philippines

National Plumbing Code of the Philippines

National Structural Code of Building

PAES 414-1:2002 Agricultural Structures – Waste Management Structures: Part 1 –
Agricultural Liquid Waste

PAES 414-2:2002 Agricultural Structures – Waste Management Structures: Part 2 –
Agricultural Solid Waste - Composting

PAES 418:2002 Processing Plant for Fresh Fruit and Vegetable

Philippine Electrical Code 2000

3 Definition

For the purpose of this standard, the following definitions shall apply:

3.1**controlled atmosphere storage**

storage in an artificial atmosphere in which the proportion of carbon dioxide and/or oxygen is precisely controlled

3.2**bulk storage**

produce is piled in room-sized bins, which exerts forces that must be resisted by the building walls

3.3

pallet bin storage

produce is placed in boxes or pallet bins which in turn are stacked in storage room

3.4

pallet

low portable platform made of wood or metal or plastic or in combination to facilitate handling, storage, or transport of materials as a unit load using a forklift

3.5

drip cooler

storage structure with continuously wetted walls

3.6

burlap

coarse cloth made of jute, flax or hemp

3.7

air cooled

storage provided with good ventilation

3.8

vapor barrier

materials used to prevent migration of moisture into a storage area

3.9

cell pack

individual divisions in a carton formed by fiberboard dividers, each cell to contain one fruit

3.10

telescopic cartons

cartons in which the cover is separate and fits snugly over the bottom part

4 Location

4.1 The location shall conform to the land use plan of the area.

4.2 There shall be provision for parking area.

4.3 The area immediately surrounding the building shall be concreted, covered with asphalt or with similar material. The access road, walkways and parking areas shall be similarly treated.

4.4 The site shall be accessible to service roads, water supply and electric lines.

4.5 The site shall be well drained.

5 Classification

5.1 According to method of storage

5.1.1 Bulk

5.1.2 Palletized

5.2 According to environment control

5.2.1 Drip cooling

5.2.2 Air-cooled

5.2.2.1 Natural convection

5.2.2.2 Forced ventilation

5.2.3 Refrigerated

5.2.4 Controlled atmosphere

6 Space requirement

6.1 For palletized storage, floor area shall be determined by calculating volume of the boxes or pallet bins and dividing the volume by the maximum stacking height and adding area for aisles, room for forklift maneuvering, and staging areas.

6.2 For bulk storage, floor area shall be determined by knowing the weight of the produce and by dividing by the bulk density and pile depth (Table 1).

Table 1 - Bulk density and pile depth for bulk storage of some vegetables

Produce	Average bulk density kg/m ³	Maximum pile depth m
Potatoes	670	4.2 - 6
Pumpkins and squash	600	0.6 - 1
Onions	650	3 - 3.6

7 Structural requirements

7.1 Roof

7.1.1 The roof structure shall be treated timber or steel with anti-rust paint.

7.1.2 Roofing materials shall be made of G.I. sheet and other steel sheeting with corrosion resistant coatings.

7.1.3 Roof vents, when provided, shall be properly screened.

7.1.4 For bulk storage, forces on roof system caused by wall pressure shall be considered in designing roof structure.

7.2 Ceilings

7.2.1 Ceilings shall be at least 2.4 m from the finished floor line for manual handling and 6m for mechanical handling.

7.2.2 Ceilings shall be constructed to prevent the collection of dirt or dust that might sift through from the areas above or fall from overhead collecting surfaces onto equipment or exposed products.

7.2.3 Ceilings shall be painted with white emulsion or latex paint.

7.3 Wall

7.3.1 The wall shall be concreted, smooth finished and properly painted. Internal surface of the walls should be painted with white emulsion or latex paint.

7.3.2 For pallet storage, wall shall be designed to withstand the pressure of piled fruit and vegetable.

7.3.3 All wall tops and ledges shall slope at 45° (Refer to Figure 1).

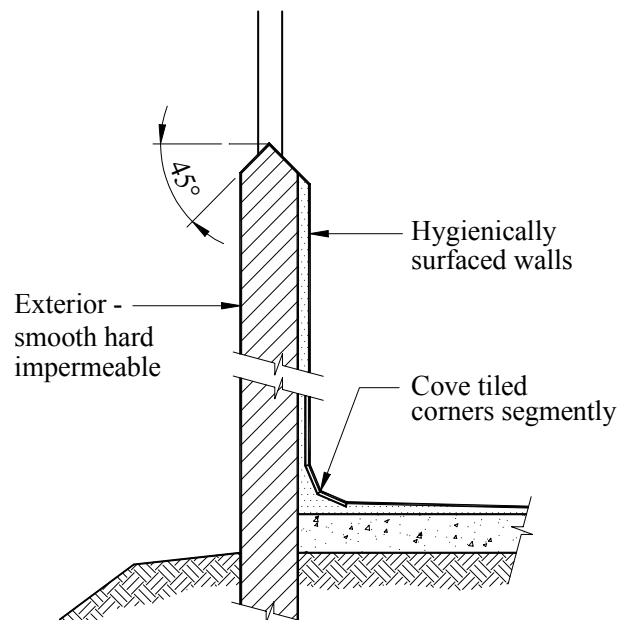


Figure 1 – Finishing of a wall

7.3.4 It should be coved to the floor-wall and at wall-to-wall junctions with a radius of 50 mm - 60 mm.

7.4 Doors and access

7.4.1 Door

Door shall be fitted with screens, air flaps or provided with air curtain. The width shall be at least 2.5 m.

7.4.2 Access

Access door shall be provided for checking the commodity without opening the main door. It shall be constructed with a glass (reinforced) panel at eye level. The width shall be 600 mm-750 mm.

7.4.3 Main entrances and exits shall be arranged so that the product generally moves in one direction through the facility.

NOTE For cold storage room, provisions for ceilings, wall and access is optional.

7.5 Floor

7.5.1 Floor shall be concreted or tiled and properly reinforced to prevent cracks. It shall be designed to withstand concentrated loads.

7.5.2 Floor height should be leveled with the height of the vehicle being used in transporting the commodity.

7.5.3 Intersection with the wall shall be coved with 50 mm - 60 mm radius.

7.5.4 The floor slope should be 2% - 4% towards the drain.

7.6 All other matters concerning structural design of the building not provided in this Standard shall conform with the provisions of the National Structural Code of Building.

8 Functional Requirements

8.1 Receiving and sorting area

Refer to **PAES 418:2002**.

8.2 Storage area

8.2.1 Drip cooling

8.2.1.1 The wall for the drip cooling should be made of burlap or porous materials and should be held in place by wire netting.

8.2.1.2 Water pipe with nozzles on the top of the wall or sprinkling hose shall be provided to trickle water down the walls.

8.2.1.3 Water collector made from curve metal sheet of gutter shall be provided.

8.2.1.4 If necessary, forced air circulation system to draw air from outside and ceiling exhaust fan to force air out should be provided.

8.2.2 Air-cooled

8.2.2.1 Natural convection

Air inlets shall be located near the floor level and outlets shall be near the roof.

8.2.2.2 Forced ventilation

There shall be provision for regulating inside temperature by a ventilation system. Entry of air should be mechanically controlled using fan and installing automatically regulated openings or dampers. Table 2 shows the recommended ventilation rates of some vegetables.

Table 2 - Recommended ventilation for selected vegetables

Produce	Ventilation (L/s)/ton
Cabbage	20-30
Carrots	20-30
Potatoes	6-10
Pumpkins and squash	15-20
Onions	10-12

8.2.3 Refrigerated

8.2.3.1 There shall be provision for pre-cooling facilities.

8.2.3.2 Refrigeration system should be designed to maintain the appropriate storage temperature and relative humidity of the commodity.

8.2.3.3 Ceiling, wall and floor shall be provided with vapor barriers and shall be insulated with minimum R-values as shown in Table 3. Annex A shows the thermal properties of selected insulating materials and refer to Annex B for the sample calculations of R-value.

Table 3 – Recommended insulation for refrigerated room

	Minimum R-Value
Ceiling	5 (R-30)
Wall	3.5 (R-20)
Floor	1.76 (R- 10)

8.2.3.4 An 80 mm air plenum should be provided between the floor and stack.

8.2.3.5 Door should be sliding type and should be made of heavy gauge metal.

8.3 Piling system

8.3.1 Stack should be about 80 mm away from outer walls and 100 mm – 120 mm away from the wall that is exposed to the sun.

8.3.2 Space between the ceiling and the stack shall be 300 mm.

8.3.3 Within a stack, a minimum of 10 mm vertical air path shall be provided between each box.

8.3.3.1 Space between stack and sides and floor shall be 150 mm – 200 mm.

8.3.3.2 Stacking height shall be up to 12 units for the cell pack and 8 units high for telescopic tray pack cartons.

8.4 Facilities and equipment

8.4.1 Lighting

8.4.1.1 Artificial lighting shall always be available for use during the night or darkened periods of the day.

8.4.1.2 Table 4 shows the recommended lighting intensity for fruit and vegetable storage.

Table 4 - Recommended lighting intensity for fruit and vegetable storage

Area	Lighting intensity* lux (lumen/m ²)
Outside the building	100
General	200
Working table	500
Refrigerated storage room	50

* Refer to Annex D

8.4.1.3 All electrical design and installation shall conform to Philippine Electrical Code.

8.4.2 Water supply and Plumbing facilities

8.4.2.1 The water supply shall be ample and potable with adequate pressure and with facilities for distribution.

8.4.2.2 Drainage and plumbing system for the fruit and vegetable storage shall be in accordance with the National Plumbing Code.

8.4.3 Toilet and hand-washing facilities

8.4.3.1 Toilets and hand-washing facilities shall be provided inside the building.

8.4.3.2 Toilet rooms shall not open directly into areas where the product is exposed unless steps have been taken to prevent airborne contamination (example: double doors, positive airflow).

8.4.3.3 Toilet rooms must have self-closing doors.

8.4.3.4 Adequate and convenient hand-washing and, if necessary, hand-sanitizing facilities should be provided anywhere in the building where the nature of employees jobs requires that they wash, sanitize and dry their hands.

8.4.4 Fire extinguishing system

Construction of fire extinguishing system shall conform with the provision of the National Building Code of the Philippines.

9 Waste disposal

For waste management, refer to **PAES 414:2002** and **PAES 414-2:2002**.

Annex A
(informative)

Thermal properties of selected insulating materials

Material	R Factor (m ² °K/W)/cm
Fiberglass batts	0.230
Fiberglass, loose	0.177
Fiberglass, board	0.277
Cellular glass	0.198
Styrofoam, extruded	0.346
Styrofoam, beadboard	0.289
Polyurethane, board	0.433
Polyurethane, foamed-in-place	0.433
Polyisocyanurate, board	0.488

Annex B
(informative)

Example calculation of R-value

A.1 Wall

	R factor (m ² °K/W)
Outside air	0.049
140 mm fiberglass	3.21
25 mm rigid insulation	0.926
13 mm plywood	0.11
Inside air	<u>0.03</u>
	4.32 [24.60 (h.ft ² °F/BTU)]

A.2 Ceiling

	R factor (m ² °K/W)
Outside air	0.049
140 mm fiberglass	3.21
50 mm rigid insulation	1.85
13 mm plywood	0.11
Inside air	<u>0.03</u>
	5.25 [29.86 (h.ft ² °F/BTU)]

A.3 Floor

	R factor (m ² °K/W)
50 mm rigid insulation	1.85
100 mm concrete	0.077
Inside air	<u>0.03</u>
	1.96 [11.12 (h.ft ² °F/BTU)]

Annex C
(informative)

Recommended conditions for storage of fresh fruits and vegetables

Commodity	Storage temperature	Relative humidity
Ampalaya	12-13	85-90
Atis	4-5.5	85-90
Avocado	13	85-90
Banana		
Cavendish, green	13-14.5	85-90
Lacatan, green	13-15.5	85-90
Saba, green	10	85-90
Beans		
Bush sitao	5.6	88-95
Dolichos lablab (batao pods)	0-1.5	90
Lima bean pods (patani)	5-6	95
Snap beans	4-7	95
Winged bean	10	90
Bottle gourd (upo)	7.5	85-90
Cabbage	0	98-100
Caimito, ripe	3	90
Carambola	9-10	85-90
Carrot	0	95-100
Cashew	0-2	85-90
Cassava	0-5	85-90
Cauliflower snowball	0	95-98
Celery	0	98-100
Chayote	7	85-90
Chico	19.5-21	85-90
Chinese broccoli	0	95-100
Citrus		
Calamondin	9-10	90
Pomelo	7.5-9	85-90
Szinkon orange	7.5-9	85-90
Valencia orange	6.5-9	88-92
Coconut	0-1.5	80-85
Corn, sweet	0	95-98
Cucumber	10-13	95
Durian	4-6	85-90
Eggplant	12	90-95
Gabi	11.5-12.5	85-90
Garlic, (bulbs), dry	10-12.5	90
Ginger	13	65
Guava	5-10	90
Guyabano	13	85-90
Horseradish	-1-0	98-100

Commodity	Storage temperature	Relative humidity
Jackfruit	13	85-90
Lanzones	11.5-14	85-90
Lettuce	0	98-100
Mango	13	85-90
Mangosteen	13	85-90
Mushroom	0	95
Muskmelon		
Honeydew	7.5	85
Cantaloup	0-2	95
Okra	7-10	90-95
Onion, green (immature)	0	95-100
Onion, red	0	70-75
Onion, white	1.1	70-75
Papaya	7-13	85-90
Passion fruit	7-10	85-90
Patola (Trichosanthes)	5.5-7	85-90
Pea, green	0	95-98
Pechay	0	95
Pepper, bell	7-10	95-98
Pepper, hot	5-10	85-95
Pepper, sweet	7-13	90-95
Pineapple	7-13	85-90
Pineapple guava	5-10	90
Potato, Irish	3.3-4.4	85
Radish, topped	0	88-92
Rambutan	12	90-95
Santol	7-9	85-90
Squash	5-10	95
Star fruit	9-10	85-90
Sweet potato	13-15	85-90
Tamarind	7	90-95
Taro root	7-10	85-90
Tomato, mature-green	18-22	90-95
Tomato, firm-ripe	13-15	90-95
Watermelon	10-15	90
White asparagus	0-2	95-100
Yams	16	70-80

Annex D
(informative)

Lighting Requirements

Lighting Intensity lux	No. of Bulbs Required per m ²							
	Incandescent lamp						Fluorescent lamp	
	25W	40W	60W	100W	150W	200W	20W	40W
500	3.935	1.989	1.052	0.520	0.314	0.226	0.682	0.266
400	3.148	1.591	0.842	0.416	0.251	0.181	0.546	0.213
300	2.361	1.193	0.631	0.312	0.189	0.136	0.409	0.160
200	1.574	0.796	0.421	0.208	0.126	0.090	0.273	0.107
150	1.180	0.597	0.316	0.156	0.094	0.068	0.205	0.080
100	0.787	0.398	0.210	0.104	0.063	0.045	0.136	0.053
50	0.393	0.199	0.105	0.052	0.031	0.023	0.068	0.027
10	0.079	0.040	0.021	0.010	0.006	0.005	0.014	0.005