DRAFT KENYA STANDARD **DKS 3024:2024**

ICS

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Solar Dryer - Code of practice for Installation

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TECHNICAL COMMITTEE REPRESENTATION

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Bioafric Energy Kenya
Strathmore University
Motorwise Valuers
Kenya Climate Innovation Centre (KCIC)
Improved Stoves Association of Kenya (ISAKENYA)
Kenya Industrial Research and Development Institute (KIRDI)
Kenya Bureau of Standards — Secretariat

REVISION OF KENYA STANDARDS

In order to keep abreast of progress in industry, Kenya Standards shall be regularly reviewed. Suggestions for improvements to published standards, addressed to the Managing Director, Kenya Bureau of Standards, are welcome.

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ICS

Solar Dryer - Code of practice for Installation

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Foreword

This Kenya Standard was prepared by the Appropriate Technology Technical Committee under the guidance of the Standards Projects Committee, and it is in accordance with the procedures of the Kenya Bureau of Standards.

Solar Dryer – Code of practice for Installation

1 Scope

This standard gives technical specification to guide in the installation of solar dryers to be used for drying different types of farm products including but not limited to cereals, vegetables, fruits, tubers, herbs, coffee berries, tea leaves, nuts, meat, fish and animal feeds.

2 Normative References

The following referenced documents 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.

KS ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods
KS 219 Specification for hexagonal and square bolts, screws, nuts and locknuts (Metric and inch threads)
KS EAS 134 Cold rolled steel sections-Specification
ISO 11963 Plastics — Polycarbonate sheets — Types, dimensions and characteristics
KS 1814 Biomass Stoves- Performance requirements
KS 2520 Domestic biogas stoves – Specification
KS 2951 Biogas systems - Code of practice for farm and industrial scale biogas systems

3 Terms and definitions

For the purpose of this document, the following definition of terms apply:

3.1
solar dryer
is a device that uses innovative technologies to harness solar energy for heat production to facilitate dehydration of matter by passing hot air in direct contact or pre-heated air through natural or forced circulation.

3.2
natural convection solar dryer
is defined as one that uses natural airflow pattern to facilitate circulation of air inside the drying area.

3.3
forced convection solar dryer
is a solar dryer that uses enhanced airflow system such as fans to circulate air inside the drying area powered by either electricity or solar energy or both.

3.4
hybrid solar dryer
is a solar dryer with additional attachment to supply heat into the drying area.

The additional attachment could be a system that uses biomass fuels, biogas, or electricity to supply alternative heat to substitute or compliment solar energy.

3.5

effective drying area

is the total surface area available for drying materials that is effectively exposed to sunlight and airflow.

3.6

direct flow solar dryer

is a type of solar dryer in which the product being dried is exposed directly to the sunlight, and the air used for drying is heated by the sun within the collector.

3.7
indirect flow solar dryer
is a type of solar dryer in which the product is not directly exposed to the sunlight but instead, a solar collector collects the sunlight and heats up a separate air stream which is then passed through the drying chamber where the product is located.

3.8
mixed flow solar dryer
is a type of solar dryer which combines elements from both direct and indirect drying systems. In this system, the drying air is heated in a solar collector, but the product is exposed to both direct sunlight and the heated air.

4 Types

The solar dryer shall either be direct flow, indirect flow, mixed-flow, natural convection, forced convection or hybrid solar dryer type.

5 Size

The size of the solar dryer to be installed shall be as agreed between the installer and the client.

5 Requirements

5.1 General Requirements

5.1.1 The outdoor body of the solar dryer shall be resistant and low weathering to exposed environment

5.1.2 Materials to be used may include but not limited to wood, stainless steel, galvanized steel, heat-resistant plastics, mild steel coated with anti-rust primer and food grade paint.

5.1.3 An appropriate air-tight material shall be used on the doors.

5.1.4 The air draught opening of the dryer shall have a mesh with air filtering ability to restrict insects and prevent debris. Preferably the mesh could be of steel or durable insect net.

5.1.5 The mesh shall be easy to clean and maintain.

5.1.6 For natural convection dryers, the inlet vent and the aeration vent shall be on opposite sides to ensure air is circulated in the entire drying chamber effectively before exiting.

NOTE: The height of the aeration vent shall be at the highest point possible to facilitate air flow.

5.1.7 If air circulation fan is installed, the aeration vent shall be on opposite side or at the center of the drying area to ensure air is circulated in the entire drying chamber effectively before exiting.

5.2 Drying Chamber

5.2.1 The material for the dry chamber trays shall be rust free and food grade.

5.2.2 If the drying chamber is made of wood, it shall be made of a highly polished plywood box held in place by angle irons.

5.2.3 Aluminium foil may be wrapped on the inside of the chamber to further reduce heat loss by radiation and to avoid moisture absorption by the wood

5.3 Aperture

5.3.1 The aperture shall be 3-4mm clear, preferably iron free and toughened glass with transitivity greater than 80% when determined as per the method in Annex A.

5.3.2 Alternatively, UV stabilized food grade polycarbonate (PC) sheet of minimum thickness of 3mm shall be used for the aperture.

5.3.3 The PC sheet shall conform to ISO 11963

5.3.4 Where a UV treated polyethylene sheet is used, the minimum thickness shall be 200microns.

5.3.5 The glass or PC used for the aperture shall be sealed with appropriate UV resistant sealant.

5.3.6 UV mark certificate from manufacturer is mandatory for the material used.

5.3.7 Other suitable materials such as Acrylic, also known as Plexiglass or PMMA (Polymethyl methacrylate), Polypropylene (PP) and Glass-Fiber Reinforced Plastic (GRP) may also be used for the aperture.

5.4 Support

5.4.1 The support for the structure shall be rigid enough to avoid any buckling during manual handling or under wind speed of 45 m/s.

5.4.2 The support for the dry chamber shall be made of mild steel frames hollow sections conforming to KS EAS 134.

5.4.4 The mild steel frame shall be coated with anti-rust either through painting or hot deep galvanized in accordance with ISO 1461

5.4.5 The pieces of metal forming the frame shall be joined by use of bolts and nuts, welding or any other suitable means that ensures rigidity of the frame

5.4.6 The bolts and nuts used shall conform to the requirements of KS 219

5.5 Absorber area

5.5.1 Absorber area shall have a minimum ratio of 4:7 to the drying chamber

5.5.2 The floor shall be made of a black absorber plate or suitable solar absorber material

5.6 Data Monitoring

For large-scale or commercial applications, advanced systems with data logging, remote monitoring, or automated control systems shall be used to provide real-time feedback on drying conditions.

6 Paint

The paint shall be low reflecting and non-toxic.

7 Hybrid Solar Dryers

7.1 Biomass Stove for Biomass Hybrid Solar Dryer

The biomass stove for installation in a hybrid solar dryer shall be constructed as per the specifications in KS 1814.

7.2 Biogas Stove for Biogas Hybrid Solar Dryer

The biogas stove for installation in a hybrid solar dryer shall be constructed as per the specifications in KS 2520.

The biogas system shall be installed as per the specifications in KS 2591.

7.3 Electrical Hybrid Solar Dryer

Maximum safety precautions shall be taken when installing a hybrid solar dryer that utilizes electric energy to supplement solar power.

NOTE 1: Electrical components shall be well insulated, and the system should have built-in safety features to prevent electrical hazards.

NOTE 2: A suitable heat exchanger should be installed depending on the type of alternative energy source selected.
NOTE 3: A thermostat or temperature sensor may be integrated into the system to help monitor the internal temperature of the dryer and automatically switch the stove on or off.

8 Performance requirements

8.1 Quality Evaluation of Dried Product

When visually inspected, the product shall be uniformly dried without signs of over-drying, discoloration, or damage.

8.2 Nutritional and Sensory Quality

8.2.1 Where applicable, the nutritional and sensory quality of the dried product shall be assessed.

8.2.2 The drying process shall not significantly degrade the sensory characteristics (e.g., color, texture, taste) and nutritional content of the dried product.

8.3 Humidity Control and Monitoring

8.3.1 The dryer shall efficiently remove moisture from the products being dried and control humidity levels to prevent mold, spoilage, or product loss.

8.3.2 Moisture sensors may be integrated in the system to ensure optimal moisture content is maintained for preservation.

8.4 Temperature Control

8.4.1 Temperature Range

8.4.1.1 The dryer shall maintain an appropriate temperature range suitable for the material being dried (e.g., fruits, vegetables, herbs, grains).

8.4.1.2 The dryer shall provide consistent temperatures without overheating, which could lead to product degradation.

8.4.2 Adjustable Settings

The dryer should allow for temperature adjustments based on the type of product being dried.

8.5 Drying Efficiency

When tested in accordance with Annex B, the dryer shall have a minimum drying efficiency of 0.5 kg/hr.

9 Labelling

The dryer shall be well labeled with the following information

a) Dryer Model
b) Effective drying area m^2
c) Effective drying volume in m^3
d) Date of Manufacture
e) Date of Installation
f) Manufacturer Name and Contact Phone number and address
g) Installer name and Contact Phone number and address
h) Applicable standard used (this standard)
i) Serial number
j) Country and city of Manufacture
k) Warranty and Guarantee period

Annex A: Transitivity Measurement

(Normative)

Equipment Needed: A light meter or photometer.

Procedure:
A.1 Set up the light source on one side of the glass sample.
A.2 Position the light meter on the opposite side.
A.3 Measure the intensity of light without the glass and then with the glass in place.
A.4 Calculate the transmittance as a percentage:

(Intensity with glass/Intensity without glass) ×100.

Annex B: Drying Efficiency Test

(Normative)

Testing the drying efficiency of a solar dryer involves evaluating how effectively it removes moisture from a product within a given period, while also assessing the energy consumption, drying time, and the quality of the dried product.

B1. Test Setup and Preparation

B1.1 Selection of Material

Choose a uniform material to dry, such as fruits, vegetables, grains, or other agricultural products. Ensure the material has an initial known moisture content.

B1.2 Pre-weighing of Sample

Weigh the material to be dried before starting the test. This will be used to calculate the moisture loss and drying efficiency.

B1.3 Environmental Conditions

Record the solar radiation (sunlight intensity), ambient temperature, and relative humidity at the beginning of the test. This helps to contextualize the drying performance.

B2. Drying Process

B2.1 Load the Material into the Dryer

Place the material in the drying chamber or trays of the solar dryer.
Ensure that airflow and ventilation are optimal.

B2.2 Monitor Temperature and Humidity

Continuously monitor the temperature inside the dryer and the humidity level. These variables should be recorded at regular intervals to assess the drying conditions during the process.

B2.3 Time Interval Measurements

Set up a regular schedule to remove and weigh samples at intervals (preferably every hour or every two hours) to track the weight reduction over time.

B3. Key Parameters to Measure During the Test

B3.1 Moisture Content

B3.1.1 Initial Moisture Content

Before starting, record the initial moisture content of the product. This can be done using a moisture meter, drying oven, or other standard techniques.

B3.1.2 Final Moisture Content

After drying is complete, weigh the product again to determine the final moisture content. This is typically done by drying the product in an oven at a standard temperature (e.g., 105°C) for a specified period and calculating the moisture loss.

B3.1.3 Moisture Removal Rate

The rate at which moisture is removed during the drying process can be calculated by comparing the initial and final moisture contents over time.

$$Moisture\ Removal\ Rate = \frac{m-n}{t}$$

Where;

m= initial moisture content

n = moisture content at time t

t= drying time (in hours)

B3.2 Drying Time

Record the total time required to reduce the moisture content of the product to a specific desired level (e.g., 10-15% moisture content). This will help evaluate how quickly the solar dryer works.

B3.3 Temperature and Humidity Inside the Dryer

Measure the internal temperature and relative humidity regularly during the drying process.
These factors directly affect drying rates, and variations in these conditions may highlight inefficiencies or optimization opportunities in the drying system.

B4. Calculation of Drying Efficiency

The drying efficiency can be calculated using either of the two methods:

A) Drying Efficiency Based on Energy Input

Drying efficiency is calculated by evaluating how efficiently the solar energy is used for moisture removal.

This is done by comparing the energy input (solar radiation) with the energy required to remove moisture from the product.

$$Thermal\ Efficiency = \frac{Energy\ \ Used\ for\ Drying}{Energy\ \ Supplied\ by\ Solar\ Radiation}$$

NOTE1: The energy used for drying is calculated based on the amount of water evaporated (latent heat of vaporization) and the moisture removed.

NOTE2: The energy supplied by solar radiation is measured using a pyranometer or by calculating the solar irradiance over time.

B) Drying Efficiency Based on Moisture Content

This is a simpler method and more direct approach and is based on the relationship between moisture removed and time

$$Drying\ Efficiency = \frac{Mass\ of\ water\ Evaporated}{Time\ Taken\ to\ Evaporate}$$

NOTE1: Mass of Water Evaporated is the difference between the initial and final mass of the material.

NOTE2: Time Taken to Evaporate is the total drying time.