



TITLE: Refrigerator or combined refrigerator and water-pack freezer: Solar direct drive without battery storage

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Contents

1. Scope	2
2. Normative references	3
3. Terms and definitions	4
4. Requirement	7
4.1 General	7
4.2 Performance	7
4.2.1 <i>Operating temperature range</i>	7
4.2.2 <i>Refrigeration cycle</i>	7
4.2.3 <i>Design of the vaccine storage compartment</i>	7
4.2.4 <i>Vaccine freeze protection classification</i>	8
4.2.5 <i>Water-pack freezing capacity (combined units only)</i>	8
4.2.6 <i>Water-pack storage compartment capacity (combined units only)</i>	8
4.2.7 <i>Temperature control</i>	8
4.2.8 <i>Thermostat</i>	9
4.2.9 <i>Temperature monitoring and thermometer</i>	9
4.2.10 <i>Indicator light</i>	10
4.2.11 <i>Autonomy</i>	10
4.2.12 <i>Minimum rated ambient temperature</i>	11
4.2.13 <i>Power system requirements and consumption</i>	11
4.2.14 <i>Condensation management and defrost</i>	11
4.2.15 <i>Lock</i>	11
4.2.16 <i>Corrosion resistance</i>	11
4.2.17 <i>Electrical safety rating</i>	12
4.2.18 <i>Markings and labelling</i>	12
4.2.19 <i>Vaccine storage advice</i>	12
4.2.20 <i>Electromagnetic compatibility</i>	13
4.3 Environmental requirements	13
4.3.1 <i>Ambient temperature range during transport and storage</i>	13
4.3.2 <i>Ambient humidity range during transport, storage and use</i>	13
4.4 Physical characteristics	13
4.4.1 <i>Overall dimensions</i>	13
4.4.2 <i>Weight</i>	13
4.5 Interface requirements	13
4.5.1 <i>Electrical components</i>	13

4.5.2	Power switch	13
4.6	Human factors	14
4.6.1	General design	14
4.6.2	Control panel, indicator light and thermometer	14
4.7	Materials	14
4.7.1	Refrigerant	14
4.7.2	Thermal insulation foaming agents	14
4.7.3	Other restricted materials	14
4.7.4	PCM	14
4.8	Warranty	15
4.9	Servicing provision	15
4.9.1	Essential spare parts and user maintenance tools/supplies:	15
4.10	Disposal and recycling	15
4.11	Instructions	15
4.12	Training	16
4.13	Verification	17
5.	Packaging	17
6.	On-site installation	17
7.	Product dossier	17
8.	On-site maintenance	18
9.	Change notification	18
10.	Defect reporting	18
	Annex 1: Temperature zone symbol for refrigerators	19
	Annex 2: Refrigerant symbols	19
	Annex 3: Fully frozen water-pack determination	20
	Annex 4: Freeze protection classification symbols for refrigerators	20
	Revision history	21

1. Scope

This specification defines the requirements for vaccine refrigerators or combined vaccine refrigerator and [water-pack](#) freezer (collectively called appliances) powered by a solar electric system with no battery. Prequalification testing will establish a [solar radiation reference period](#) below which the appliance should not be used and the maximum [autonomy](#) that the appliance can achieve. PQS specification **E003/PV01** specifies a compatible **Type 2** solar power system to directly power the appliance. Three temperature zone designations are described: [hot zone](#) (required), [moderate zone](#), and [temperate zone](#). In addition, appliances are tested to establish a [minimum rated ambient temperature](#) designation and [freeze protection classification](#).

Appliance design must account for performance degradation over the 10-year target life of the appliance in order to sustain [acceptable temperature range](#) and [water-pack freezing capacity](#) and other appliance features (if included).

The build quality of the appliance and all ancillary components must be consistent with the conditions under which these appliances are used, including, but not limited to, the following:

- Transport by air, sea and over rough, dusty road surfaces,
- High temperatures in transport, storage and operation,
- Low temperatures in transport, storage and operation,
- High humidity in transport, storage and operation,
- Operating locations with high wind and high density of dust particles,
- Operating locations near corrosive marine environments,
- Users with inconsistent training, and/or
- Users with no specific maintenance tools.

2. Normative references

(Use most recent version of each reference)

EMAS: European Union Eco-Management and Audit Scheme.

EN ISO 6270-1 / ASTM D2247 / EN 13523-26: Determination of resistance to humidity – Part 1: Continuous condensation.

EN ISO 6270-2 / EN 13523-25: Determination of resistance to humidity - Part 2: Procedure for exposing test specimens in condensation-water atmospheres. GHS Rev 5. United Nations: Globally Harmonized System of Classification and Labelling of Chemicals.

IEC 60335-1: Amendment 1: Household and similar electrical appliances - Safety - Part 1: General requirements.

IEC 60335-2-24: 2007: Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers.

IEC 60364-1: 2005: Low -voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions.

IEC 61000-6-1 edition 2.0: 2005: Electromagnetic compatibility (EMC) Generic standards - Immunity for residential, commercial and light-industrial environments.

IEC 61000-6-3 edition 2.1: 2011: Electromagnetic compatibility (EMC) Generic standards - Emission standard for residential, commercial and light-industrial environments.

IEC 62552: 2007: Household refrigerating appliances – Characteristics/tests.

ISO 2409: 2013: Paints and varnishes – cross cut test (external cabinet).

ISO 6272 / EN 13523-5: Impact resistance - external cabinet.

ISO 9001: Quality Management Systems – Requirements.

ISO 14001: 2004: Environmental management systems - Requirements with guidance for use.

ISO 20282-1: 2006: Ease of operation of everyday products - Part 1: Context of use and user characteristics.

ISO/IEC 17025: 2005: General requirements for the competence of testing and calibration laboratories.

WHO/PQS/E003/PV01: Performance specification: Solar power system for compression-cycle vaccine refrigerator or combined refrigerator and water-pack freezer.

WHO/PQS/E003/PV01-VP1.2: Type-examination protocol: Solar power system for compression-cycle vaccine refrigerator or combined refrigerator and water-pack freezer.

WHO/PQS/E003/PV01-VP2.2: Quality assurance protocol: Solar power system for compression-cycle vaccine refrigerator or combined refrigerator and water-pack freezer.

WHO/PQS/E003/RF05.4-VP.4: Independent type testing protocol: Refrigerator or combined refrigerator and water-pack freezer: Solar direct drive without battery storage.

WHO/PQS/E005/IP01: Water-packs for use as ice-packs, cool-packs and warm-packs.

WHO/PQS/E006/TH02: Fixed gas or vapour pressure dial thermometer.

WHO/PQS/E006/TH06: Integrated electronic maximum-minimum thermometer, with factory programmed alarms, for vaccine refrigerators and freezers

WHO/PQS/E006/TR06: 30-day electronic temperature logger.

WHO/PQS/E003/BC01.1: Global asset identification

3. Terms and definitions

Acceptable compartment humidity: The acceptable compartment humidity is 55% or lower at +2-8°C during relevant verification testing. However, transient excursions during testing above this value will be tolerated, with the following limits:

- No excursion may exceed 65% at +2-8°C when the appliance is supplied with power and after any initial starting period defined in verification protocols.
- The average compartment humidity during relevant verification testing remains 55% or lower at +2-8°C when the appliance is supplied with power and after any initial starting period defined in verification protocols.

Acceptable temperature range: The acceptable temperature range for storing vaccine is +2°C to +8°C. However, transient excursions outside this range will be tolerated, within the following limits:

- No excursion must exceed +20°C ($\pm 0.5^\circ\text{C}$) for any amount of time,
- No excursion must drop below -0.5°C for any amount of time,
- No excursion must drop below 0°C for longer than 1 hour, and
- Following an excursion below 0°C, the appliance must return to safe operating temperature (i.e. consistently between +2°C and +8°C) within two hours. This duration will be measured from the moment the temperature drops below 0°C and up until it returns to +2°C.

The cumulative effect of any excursions within the above range will be assessed over the five-day period of the *day/night* test. For this test, the calculated mean kinetic temperature (MKT)¹ must remain within the range +2°C to +8°C when the default activation energy is set at 83,144 kJ per mol. Using the recorded temperature data, an MKT figure will be calculated for each sensor. The worst-case result will determine the

¹ Refer to Seevers, R. et al. The Use of Mean Kinetic Temperature (MKT) in the Handling, Storage and Distribution of Temperature Sensitive Pharmaceuticals. Pharmaceutical Outsourcing, May/June 2009.

outcome of the test. Excursions in other tests will be noted and must not exceed the defined upper and lower limits.

Autonomy (freezer): Time in hours that a solar direct drive water-pack freezer can maintain the minimum required capacity of fully frozen water-packs under low solar radiation conditions (e.g. rain). Autonomy is measured as described in

E003/RF05-VP.6.

Autonomy (refrigerator): Time in hours that a solar direct drive refrigerator, or combined refrigerator and water-pack freezer, can maintain the vaccine load between +2°C and +8°C under low solar radiation conditions (e.g. rain). Autonomy is measured as described in **E003/RF05-VP.6**. Installation site autonomy is determined as described in **E003/PV01** – Section 4.1.2.

Ambient humidity: The relative humidity (%) of the chamber in which the appliance is being tested.

Cool-down time: The time required to initially cool an appliance to achieve stable operating conditions within the acceptable temperature range for vaccine storage and achieve its' full autonomy time.

Compartment humidity: The relative humidity (%) of the vaccine compartment of the appliance.

Freezing temperature (on walls/lining of vaccine compartment):

For sensors placed in direct contact with the walls/lining of the vaccine compartment, freezing temperature is defined as any of the following conditions:

- Excursion between -0.5°C and 0°C for longer than one hour,
- Excursion equal to or below -0.5°C for any amount of time, and/or
- Inability to return to safe operating temperature (i.e. consistently between +2°C and +8°C) within two hours following an excursion equal to or below 0°C

Freeze protection classification: The freeze protection classification is based on the number of user interventions required to ensure freeze protection.

- **Grade A, user-independent freeze protection (UIFP):** when the appliance is used within its nominated temperature range (upper hot zone temperature +43°C and minimum rated ambient temperature) there is no intervention required by the user to ensure that the vaccines will not be exposed to freezing temperatures outside of the acceptable temperature range, whatever the position of the vaccines in the vaccine storage compartment.
- **Grade B, user-dependent freeze protection (UDFP):** Even if the appliance is used within its nominated temperature range, the user must comply with a procedure provided by the legal manufacturer and requiring one level of intervention (e.g. the requirement to use baskets or any other single item constitutes one level of intervention by the user) in order to ensure that the vaccines will not be exposed to freezing temperatures outside of the acceptable temperature range.
- **Grade C, user-dependent freeze protection (UDFP):** Even if the appliance is used within its nominated temperature range, the user must comply with a procedure provided by the legal manufacturer requiring more than one level of intervention (e.g. the requirement to use baskets and insulation barriers or covers) in order to ensure that the vaccines will not be exposed to freezing temperatures outside of the acceptable temperature range.

Gross volume: The measured volume of the airspace inside the internal compartment of the appliance with the door or lid shut. For combined appliances, the gross freezer volume and the gross refrigerator volume are reported separately.

Hot zone: Hot zone units must operate at a steady +43°C ambient temperature and over a +43°C/+25°C day/night cycling temperature range.

Humidity control: A functional capability of a vaccine storage compartment, by which relative humidity levels are controlled while power is available such that limited or no condensation accumulates on compartment, vial or secondary carton surfaces and mould growth is inhibited.

Installation: The appliance specified in this document, connected to a Type 2 solar power system complying with specification **E003/PV01**.

In writing: Communication by letter, fax or email.

Legal manufacturer: The natural or legal person with responsibility for the design, manufacture, packaging and labelling of a product or device before it is placed on the market under the person's own name, regardless of whether these operations are carried out by that person or on that person's behalf by a third party.

Minimum rated ambient temperature: The lowest constant ambient temperature at which the acceptable temperature range can be maintained with a full vaccine load. In addition to the day/night test, all appliances must be able to operate at a continuous minimum ambient temperature of +10.0°C or lower whilst maintaining the acceptable temperature range.

Moderate zone: Moderate zone appliances must operate at a steady +27°C ambient temperature and over a +27°C/+10°C day/night cycling temperature range.

Montreal Protocol: Montreal Protocol on Substances that Deplete the Ozone Layer.

Phase change material (PCM): A material, other than water, which changes state between solid and liquid or changes between two different solid crystallization states over a defined temperature range, absorbing or releasing heat during the phase change. This process is reversible and can be useful for thermal control in cold chain devices and products.

Primary container: Vial, ampoule, prefilled device, plastic dispenser or tube containing vaccine or diluent. Some products are supplied in a light card carton containing a single vial, ampoule, vial pair, vial-ampoule pair or prefilled device.

Reseller: A commercial entity, licensed to act on behalf of a legal manufacturer, and which carries product liability and warranty responsibilities no less onerous than those carried by the legal manufacturer.

Solar radiation reference period: The minimum average daily solar radiation on the plane of the solar array that is required to properly power the solar refrigerator, or combined refrigerator and water-pack freezer, expressed in kWh/m²/day.

Temperate zone: Temperate zone units must operate at a steady +32°C ambient temperature and over a +32°C/+15°C day/night cycling temperature range.

User-Dependent Freeze Protection (UDFP): Refrigeration technology that requires appliance users (e.g. healthcare workers) to perform specific actions (user interventions) in order to ensure vaccine protection against freezing temperatures (e.g. store vaccines in baskets, away from compartment wall surfaces).

User-Independent Freeze Protection (UIFP): Refrigeration technology that requires appliance users (e.g. healthcare workers) to perform no specific actions (user interventions) in order to ensure vaccine protection against freezing temperatures.

User intervention: Any activity that is required to be executed by appliance users (e.g. healthcare workers) in order to ensure vaccine protection against freezing temperatures. Activities could include, but are not limited to, basket storage, storage compartment covers, thermostat/fuel adjustment, placement of removable liners or barriers, charging a battery, or thermally conditioning the appliance or components thereof.

Vaccine net storage capacity: The net storage capacity is the space where it is suitable (both thermally and ergonomically) to store vaccines with any components necessary to operate within the acceptable temperature range fully prepared and in place. If a legal manufacturer would declare more than one vaccine storage capacity for the same

internal and external dimensions, they must prequalify with different branding, one model for each different storage volume. This capacity will be published as volume in litres.

[Water-pack](#): A flat, leak proof, plastic container, filled with tap water, complying generally with specification **PQS/E005/IP01**.

[Water-pack freezing capacity](#): The daily maximum weight and number of water-packs which can be fully frozen, in one batch, during a 24-hour freezing cycle.

[Water-pack storage capacity](#): The maximum number of fully frozen water-packs that can remain fully frozen at the end of water-pack storage compartment testing.

4. Requirement

4.1 General

Solar powered vaccine refrigerators or combined vaccine refrigerator and [water-pack](#) freezers (appliances) are used primarily in areas without any electricity, or where there is less than eight hours of reliable electricity over a typical day.

Reliability, durability and effective maintenance are essential for a successful [installation](#). The associated power system must be designed to match both the appliance power consumption and local climate conditions (i.e. ambient temperatures and solar radiation resource). All appliances must fully meet the stated performance requirements with a [solar radiation reference period](#) of 3.5 kWh/m²/day and [hot zone](#) (+43°C) test temperatures. In addition, manufacturers may offer appliances suitable for [hot zone](#) and a lower temperature zone and/or lower [solar radiation reference period](#).

Net vaccine storage capacity bands of the refrigerator are based on the capacity bands prescribed and utilized by UNICEF SD. These are: < 30 L; 30 L < 60 L; 60 L < 90 L; 90 L < 120 L; 120 L < 150 L, ≥150 L and above.

4.2 Performance

4.2.1 *Operating temperature range*

The operating temperature range is indicated on the temperature zone rating sticker that is attached to the front of the appliance (see Annex 1). All appliances must be able to maintaining the [acceptable temperature range](#) in the vaccine storage compartment when operating in the [hot zone](#) (+43°C) and at a [minimum rated ambient temperature](#) of +10°C or lower.

4.2.2 *Refrigeration cycle*

Refrigeration cycle must be an electrically powered compression-cycle unit or thermoelectric appliance operating with input of direct current (DC) electricity generated with solar energy.

4.2.3 *Design of the vaccine storage compartment*

The vaccine storage compartment must be designed so that no part which is outside the [acceptable temperature range](#) can be used to store vaccines, either by inadvertent or deliberate misuse. As per the [freeze-protection classification](#) features, appliances

complying with this requirement without demanding any intervention from the user will be published as [Grade A](#). Others will be published as [Grade B](#) or [Grade C](#) depending on the level of interventions required.

Areas of an otherwise acceptable appliance which are too warm or too cold must be excluded from vaccine storage by design. The vaccine storage compartment must provide some means (such as baskets) to enforce physical separation between the vaccines and any surfaces that potentially have condensate on them (such as the floor, ceiling and/or walls of the compartment).

4.2.4 Vaccine freeze protection classification

The vaccine [freeze protection classification](#) is indicated on the [freeze protection classification](#) sticker attached to appliance front (see Annex 3). The amount of [user intervention](#) required to ensure that the vaccines will not be exposed to [freezing temperatures](#), when the appliance is used within its nominated temperature range and [minimum rated ambient temperature](#), will be classified and reported as follows:

- **Grade A, user-independent freeze protection (UIFP):** when there is no [user intervention](#) required to ensure that the vaccines will not be exposed to [freezing temperatures](#) whatever the position of the vaccine in the vaccine storage compartment.
- **Grade B, user-dependent freeze protection (UDFP):** when the user must comply with a procedure provided by the [legal manufacturer](#) and requiring one level of [user intervention](#) (e.g., the requirement to use baskets to avoid vaccine [freezing temperatures](#) constitute one level of [user- intervention](#)).
- **Grade C, user-dependent freeze protection (UDFP):** when the user must comply with a procedure provided by the [legal manufacturer](#) requiring two or more levels of [user interventions](#) (e.g., a refrigerator that not only requires the use of baskets but also requires use of removable thermal barriers constitutes two levels of [user intervention](#)).

4.2.5 Water-pack freezing capacity (combined units only)

In combined units with freezer compartment, a minimum of 1.6 kg and not less than 2.4 kg per 50 litres of gross freezer volume must be frozen per 24 hours. Some overnight ice loss is acceptable – see clause 4.2.7.

4.2.6 Water-pack storage compartment capacity (combined units only)

The freezer compartment to hold a minimum of 3.2 kg of fully frozen [water-packs](#) and at least twice the daily [water-pack freezing capacity](#) determined by **E003/RF05 VP.6**. The [water-packs](#) must comply with **E005/IP01**. These may be frozen gradually over several days. Some overnight ice loss is acceptable – see clause 4.2.7.

4.2.7 Temperature control

Refrigerator compartment: The zone within the vaccine compartment that is designated for vaccine storage must remain within the [acceptable temperature range](#)

during any continuous ambient temperature test(s) or day/night cycling temperature test. Combined units must achieve this performance with or without [water-packs](#) in the [water-pack](#) compartment.

Water-pack freezing compartment: The compartment (if present) must be capable of producing fully frozen [water-packs](#) for use by health workers at the beginning of each working day. Under the [water-pack](#) freezing tests, the temperature of the [water-pack](#) freezing compartment is permitted to exceed 0°C during the 12-hour night phase and the first three hours of the 12-hour solar phase. The net amount of fully frozen [water-packs](#) remaining under worst -case overnight test conditions and day/night cycling per **E003/RF05 VP.6** will be visually estimated and reported.

4.2.8 *Thermostat*

The thermostat must be set to prevent freezing in any part of the vaccine storage compartment. The thermostat must be effective throughout the ambient operating temperature range (down to the [minimum rated ambient temperature](#) – see clause 4.2.13). It must be designed so that it cannot be adjusted by the user. A means for adjustment by a technician is acceptable provided the device is protected from user interference (e.g. by location within the appliance cabinet). Alternatively, programmable thermostats may be password-protected. Bulb and capillary tube thermostats are not acceptable.

4.2.9 *Temperature monitoring and thermometer*

The refrigerator compartment must be equipped with a 30-day temperature logger device that supports the transfer of data to another system for analysis purposes. Acceptable options include currently prequalified disposable 30-day temperature logger complying with **E006/TR06**, with or without an external sensor lead, located in an integrated holder within the vaccine storage compartment. The holder must be positioned so that the device can easily be read by the health worker, and must be located so that temperature readings are taken in the minimum temperature zone within the compartment.

Each refrigerator will also be equipped with a permanent externally readable thermometer either:

- **Option A:** Externally readable cabinet-mounted gas or vapour pressure dial thermometer complying with PQS specification **E006/TH02**.
- **Option B:** Externally readable cabinet-mounted electronic thermometer conforming to PQS specification **E006/TH06**. Dry cell batteries must not be used.
- **Option C:** Electronic thermometer powered by a photovoltaic cell conforming to PQS specification **E006/TH06** which forms part of the device. This type draws no power from the appliance in which it is installed.

4.2.10 Humidity control

NOTE: As of the publishing of this specification version, refrigerators will be required to be tested for humidity control as part of the laboratory verification protocol, but compliance with the requirement directly below will not be required until publishing of an updated version of this specification document. The intended time frame will be to require compliance as of January 2023, pending review of equipment performance tests up to that time and publication of updated specifications and verification protocols.

Refrigerator compartment: The refrigerator compartment must have humidity control. The zone within the vaccine compartment that is designated for vaccine storage must remain within acceptable compartment humidity levels during humidity control testing as specified in the verification protocol. Combined units must achieve this performance with or without water-packs in the water-pack compartment.

Water-pack freezing compartment: Not applicable

4.2.11 Indicator light

A minimum of one green LED indicator light is required to be located on the front or top of the appliance to alert users that the cooling system is actively operating. A constant green LED light is required to indicate that the compressor or cooling system is active and the light must go off when the compressor or cooling system is off.

Optionally, additional indicator lights may be added to indicate other operating conditions including temperature and faults.

4.2.12 Autonomy

All solar direct drive refrigerators must prequalify with at least a minimum [autonomy](#) of three days at the minimum [solar radiation reference period](#) and when tested for the [hot zone](#). [Autonomy \(refrigerator\)](#) is determined by testing in accordance with **E003/RF05-VP.6**. This prequalification testing determines the [autonomy](#) of the refrigerator, and the prequalified appliance will be limited to [installation](#) sites where the refrigerator [autonomy](#) meets or exceeds the [installation](#) site [autonomy](#) requirements².

Site [autonomy](#) is determined by the methods described in **E003/PV01** clause 4.1.2. [Installation](#) site conditions may require [autonomy \(refrigerator\)](#) of more than three days.

All solar direct drive freezers must prequalify with a minimum [autonomy](#) of overnight (0.5 days) at the minimum [solar radiation reference period](#) and when tested for the [hot zone](#). The minimum [autonomy \(freezer\)](#) is confirmed by testing in accordance with **E003/RF05-VP.6**

² Refrigerator [autonomy](#) must always meet or exceed the [autonomy](#) requirement of the [installation](#) site.

4.2.13 *Minimum rated ambient temperature*

All models must be able to operate at a continuous [minimum ambient temperature](#) of +10.0°C or lower whilst maintaining the [acceptable temperature range](#). The maximum performance rating is achieved if the vaccine load remains within the [acceptable temperature range](#) at -10°C. A freeze-prevention circuit may be required to protect against freezing at low ambient temperatures.

4.2.14 *Power system requirements and consumption*

Compatible **Type 2** solar power system to directly power the appliance is specified in **E003/PV01**, with power capacity (Watts) equal to or greater than the power system capacity used for PQS prequalification testing. If supplied, the [legal manufacturers](#) must certify compliance.

Solar module voltage up to 45 volts open circuit (Voc at Standard Test Condition of solar radiation 1000W/m², cell temperature +25°C, air mass 1.5) is acceptable provided all electrically powered system components are integrated in such a way that performance and component life is not reduced by voltage input from the solar array.

No standard is set for power consumption; however, performance data will be published including power consumption (Watt hours/day) and the cooling system percentage on-time over the 12-hour solar phase.

4.2.15 *Condensation management and defrost*

The conditions within the zone designated for vaccine storage must be designed so that vaccine [primary containers](#) and vaccine cartons are not exposed to levels of humidity which may cause damage to cartons or [primary container](#) labels or create a risk of mould growth.

To alleviate humidity damage [legal manufacturers](#) are to include refrigerator design features and/or provide containers for vaccine storage. Condensate and defrost drainage must be provided in all refrigerator and freezer compartments. If used, the defrost switch (or switches) must be accessible to the user without tools but must be protected from accidental changes in position.

4.2.16 *Lock*

The door or lid must be fitted with a lock. Two keys are to be supplied with every unit.

4.2.17 *Corrosion resistance*

The [legal manufacturer](#) must certify compliance that internal and external cabinet, lid and frame are protected against corrosion as appropriate to **EN ISO 6270-1 / ASTM D2247 / EN 13523-26, EN ISO 6270-2 / EN 13523-25, ISO 6272 / EN 13523-5 and ISO 2409: 2013.**

4.2.18 Electrical safety rating

The [legal manufacturer](#) must certify compliance with **IEC 60335-1**, **IEC 60335-2-24** and **IEC 60364-1**.

4.2.19 Markings and labelling

If used, compressors must be marked with the blue identifying symbol shown in Annex 2. In addition, the cabinet must be permanently marked, near the compressor position, with the chemical name of the refrigerant or with the refrigerant number, formula or proportion (for blended refrigerants).

Appliances operating on R600a must be marked with the warning symbols shown in Annex 2.

Appliances not utilizing compressor-based cooling methods must be marked identifying any refrigerant and/or heat transfer fluids used including, but not limited to, the chemical name, formula or proportion (for blended refrigerants).

All appliances must label hazardous materials and include a Safety Data Sheet. Label and Safety Data Sheets must comply with the Globally Harmonized System for the Classification and Labelling of Chemicals **GHS Rev.5**.

The appliance must carry the following additional information fixed to the front of the cabinet: [manufacturer](#) and model number (unless already located on the front of the unit), serial number, date of manufacture, PQS identification number, applicable service phone number and website URL. This label to remain readable for the expected life of the appliance.

All appliances require an asset identification label (bar code) as specified in **WHO/PQS/E003/BC01.1**: Global asset identification. Effective date June 30, 2020.

4.2.20 Vaccine storage advice

All appliances must carry a factory-fitted non-removable label, designed to last the lifetime of the appliance and carrying the following information:

- **Vaccine refrigerators:** Vaccine storage instructions.
- **Combined appliances:** Vaccine storage instructions and [water-pack](#) freezing instructions.

The instructions should be fixed to the lid of chest appliances and near the top of the door on upright appliances. Instructions should be in one of the languages specified in clause 4.11 and as indicated by the purchaser at time ordering. If removable baskets are required to avoid [freezing temperatures](#) fix a multilingual warning within the refrigerator instructing users to “*Store vaccine in baskets only*”, or other appropriate instruction.

4.2.21 *Electromagnetic compatibility*

The [legal manufacturer](#) must certify compliance with the requirements of the latest edition of **IEC 61000-6-1** and **IEC 61000-6-3**.

4.3 Environmental requirements

4.3.1 *Ambient temperature range during transport and storage*

The ambient temperature range during transport and storage is $-30^{\circ}\text{C} < +70^{\circ}\text{C}$ when the product is inactivated.

4.3.2 *Ambient humidity range during transport, storage and use*

The ambient humidity range during transport, storage and use is $5\% < 95\%$ RH, non-condensing.

4.4 Physical characteristics

4.4.1 *Overall dimensions*

To allow for manoeuvring through corners, corridors and doorways, the minimum dimension of the product (either length, width or height) should not exceed 710 mm; exceptionally, a minimum dimension up to 830 mm can be accepted, but this will restrict the number of sites where the appliance can be installed. The maximum dimension must not exceed 1700 mm and the maximum diagonal (corner to corner) dimension must not exceed 1850 mm.

4.4.2 *Weight*

Mechanical lifting equipment will typically not be available at the [installation](#) sites. It is recommended that the appliance and any associated components be designed for lifting in such a way that no single worker is required to carry more than 25 kg whilst working on their own, or in a group.

4.5 Interface requirements

4.5.1 *Electrical components*

All electrical components must be compatible with a Type 2 solar power system as specified in specification **E003/PV01**. The appliance must be equipped with a locking female and male coupler system (“plug and play”) that is compatible with the solar array interconnection cable and polarity.

4.5.2 *Power switch*

Each appliance to provide an *on* and *off* power switch that is readily accessible to the user, either on the outside of the appliance cabinet or in a wall-mounted switch within one metre of the appliance. Plug and play solar array cable connectors (i.e. locking female and male coupler system) are not acceptable for on and off switching of the solar power system or appliance.

4.6 Human factors

4.6.1 *General design*

The product must be useable by the widest practicable range of active health workers, regardless of age, gender, size or minor disability, including colour blind users and long-sighted people without glasses, in accordance with the general principles laid out in **ISO 20282-1: 2006**.

4.6.2 *Control panel, indicator light and thermometer*

Control panel, indicator light, thermometer and other visual displays may be positioned on the front of the unit preferably as close to eye level as possible. Alternatively, they may be mounted on top of the unit at a height not exceeding 1.3 metres. If a low-level position is essential, the display should be aligned so that it can easily be read without the user having to squat or kneel down. The on and off and/or defrost switch, if present, should be recessed or otherwise protected from accidental change in position.

4.7 Materials

4.7.1 *Refrigerant*

Hydrocarbon (HC) refrigerants such as R600a or other gases with global warming potential (GWP) ≤ 11 and zero ozone-depletion potential (ODP) are required. Existing appliances with HCFC refrigerants including R134a will be phased out over a transition period of four years from issue date of this specification. The suitability of alternative refrigerant gases will continue to be assessed and preference will be given to appliances that use gases with low GWP.

4.7.2 *Thermal insulation foaming agents*

Any gas complying with the limitations and deadlines set by the [Montreal Protocol](#) on the elimination of ozone-depleting chemicals.

4.7.3 *Other restricted materials*

The appliance and its constituent components, must not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated biphenyl ethers (PBDE).

4.7.4 *PCM*

PCM - Integrated thermal buffer materials may be used to prevent freezing temperatures from propagating to the [vaccine storage compartment](#) or for other thermal purposes. The buffer material may be PCM-based but if so, must comply with **WHO/PQS/E005/PCMC0.1– PCM** specification for phase-change material containers.

4.8 Warranty

The appliance must be covered by a three-year replacement warranty in the event of any component failure arising from defective design, materials or workmanship.

4.9 Servicing provision

The appliance and solar power system must be designed to achieve a low-maintenance life of not less than 10 years apart from routine defrosting, cleaning and solar array cleaning and shading prevention.

4.9.1 *Essential spare parts and user maintenance tools/supplies:*

All sites are to be supplied with one complete user maintenance kit consisting of all necessary operations and maintenance tools as proposed by the [legal manufacturer](#). Based on product design and requirements the type and quantity of spare parts, basic [installation](#) tools/supplies, user and technician maintenance manuals (see clause 4.11), must be determined and agreed upon in advance of order placement. As a minimum, each appliance to be supplied with 10 spare fuses of all fuse size and type used in the appliance. The spares fuses are to be attached within or on the appliance.

[Legal manufacturers](#) are to publish a list of spare parts recommended for purchases of 10 and 50 appliances and power systems. The [legal manufacturer](#) must ensure supply of spare parts for a minimum of five years from the time of cessation of the last production of equipment. Spare parts are to be provided in kit form for storage in appropriate quantities at National or Sub-national level in the purchasing country, as agreed with the purchasing agency.

4.10 Disposal and recycling

The [legal manufacturer](#) must provide information to the buyer on the hazardous materials contained within the system and suggestions for resource recovery/recycling and/or environmentally safe disposal. For [legal manufacturers](#) from the European Union WEEE compliance in accordance with European Union Directive **2002/96/EC** is mandatory.

4.11 Instructions

Each appliance to include a separate user manual and technician [installation](#) manual in Arabic, English, French, Mandarin Chinese, Russian and Spanish. An English version of all instructions and manuals are required to be supplied at time of laboratory testing. Instructions to include easy to understand visuals whenever possible to avoid reliance on text.

The user manual must include the following information:

- Health and safety guidance,
- Basic operations description, and

- [Cool-down time](#) instructions to assure both acceptable temperatures and full [autonomy](#) is achieved, and
- Preventive maintenance tasks (e.g. daily, weekly, and monthly).

The technician [installation](#) manual must include the following information:

- Health and safety guidance,
- Detailed operations description,
- [Cool-down time](#) instructions to assure both acceptable temperatures and full [autonomy](#) is achieved,
- Correct handling to avoid appliance damage and for the safety of handling persons,
- [Installation](#) procedures,
- Compatible solar power system voltage,
- Preventive maintenance tasks (e.g. daily, weekly and monthly),
- Corrective maintenance procedures,
- Diagnostic and repair procedures,
- Itemised list of spare parts including part numbers,
- End-of-life resource recovery and recycling procedures, and
- User training guidance.

Printed user-operations and maintenance instructions specifically directed at the health centre or store staff must be pictorial. All key information must be summarized on a single pictogram sheet fixed onto the appliance lid or near the top front of chest appliances and near the top of the door on upright appliances. The sheet must be sufficiently durable to last the life of the appliance.

[Installation](#), repair and servicing instructions must be supplied in printed format, and optionally on DVD and/or online to instruct the [installation](#) technician [installation](#) standards and practices specific to the appliance and its power system.

4.12 Training

If requested, all [legal manufacturers](#) are required to have the capability of providing in-person training in the countries where their product is deployed. Training may be delivered by the [legal manufacturer](#), manufacturer's representative or [reseller](#). The [legal manufacturer](#) must provide user training guidance to enable [installation](#) technicians to present user training. In addition, supporting video material supplied on

DVD and/or online can be supplied to assist the instructor when delivering on-site user training.

4.13 Verification

In accordance with PQS Verification Protocol **E003/RF05-VP.6**

5. **Packaging**

Materials used for packaging the finished appliance are to be free of ozone-depleting compounds as defined in the [Montreal Protocol](#).

The packaging must be a sturdy export-quality and of a commercial standard that will provide adequate protection of the goods for carriage by air, sea and/or road to final destinations worldwide, including remote locations under adverse climatic and storage conditions and high humidity. The packaging must be not less than 17kN edge crush resistance with minimum 60% remaining with 90% humidity at a temperature of +70°C (tropical conditions).

To avoid destructive unpacking prior to [installation](#), [legal manufacturers](#) are encouraged to add a re-sealable observation opening in their packaging to aid inspectors in finding labelling and/or placing additional markings prior to [installation](#). Instructions on the packaging alerting inspectors to use of the opening and what information will be revealed are also advised.

The general specification of shipping containers will be subject to agreement with the individual procurement agencies.

6. **On-site installation**

Not required.

7. **Product dossier**

The [legal manufacturer](#) or [reseller](#) must provide WHO with a prequalification dossier containing the following:

- Dossier examination fee in US dollars.
- General information about the [legal manufacturer](#), including name and address.
- Unique identification reference for the appliance type.
- Brand name of the appliance.
- Full specifications of the appliance being offered, covering all the requirements set out in this document, including details of product marking and traceability.
- Full details of the recommended compatible Type 2 solar power system (see specification **E003/PV01**).
- A comprehensive set of photographs including a three-quarter view of the appliance with the door open. Take additional photographs showing all external surfaces of the unit, the interior layout, the compressor or cooling

system and a close-up of the thermometer, indicator light(s), the control(s), control panel and any special features.

- Certified photocopies of all type-approvals obtained for the appliance and/or its components, including CE marking and the like.
- Certified photocopies of the [legal manufacturer's ISO 9001](#) quality system certification.
- Where relevant, certified photocopies of the [legal manufacturer's ISO 14001](#) certification, EMAS registration or registration with an equivalent environmental audit scheme. Conformity with an environmental audit scheme is not mandatory; however, preference will be given to manufacturers who are able to demonstrate compliance with good environmental practice.
- Where available, laboratory test report(s) proving conformity with the PQS equipment performance specifications.
- Indicative cost of the appliance per unit, per 10 units and per 100 units, EXW (Incoterms 2010) including appliance and solar power system.

8. On-site maintenance

Maintenance will be carried out by the end-user and/or their agents.

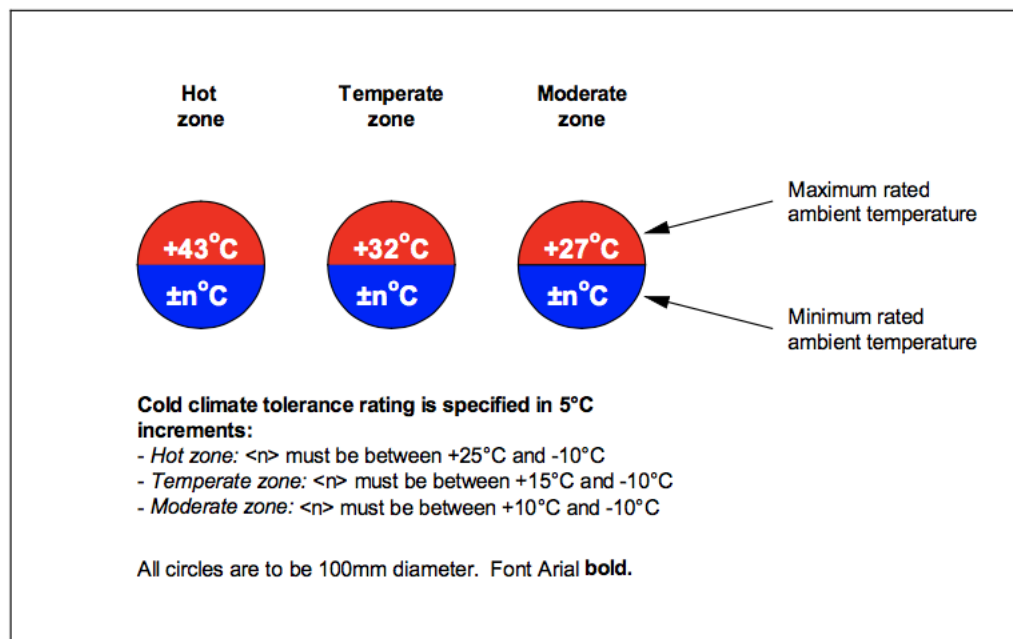
9. Change notification

The [legal manufacturer](#) or [reseller](#) must advise WHO [in writing](#) of any changes which adversely affect the performance of the appliance after PQS prequalification has taken place. Any change that WHO considers would alter the test results obtained against the PQS verification protocol **E003/RF05-VP.6** will result in a request for the appliance to be retested.

10. Defect reporting

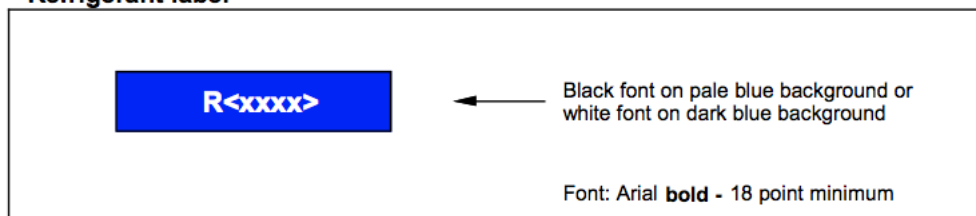
The [legal manufacturer](#) or [reseller](#) must advise WHO and the UN purchasing agencies [in writing](#) in the event of safety-related appliance and/or solar power system recalls, component defects and other similar events. If requested to do so by WHO/UNICEF, the manufacturer must submit a report to WHO/UNICEF stating the number of affected systems and the number of component repairs/replacements provided, together with copies of any associated field reports.

Annex 1: Temperature zone symbol for refrigerators



Annex 2: Refrigerant symbols

Refrigerant label



R600a warning symbol



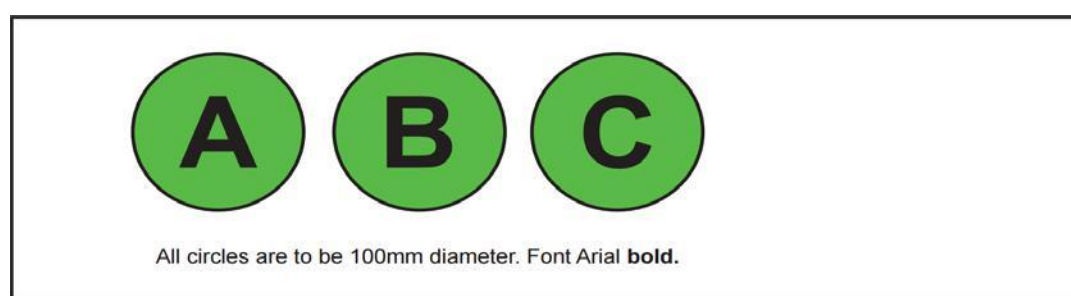
Annex 3: Fully frozen water-pack determination

The following tests are used to determine whether a [water-pack](#) is fully frozen, partially frozen or unfrozen. While the assessment is not 100% accurate, misclassifications are usually conservative in nature: [water-packs](#) that are fully frozen are sometimes classified as partially frozen rather than partially frozen [water-packs](#) being classified as fully frozen. A fully frozen [water-pack](#) contains only ice. A partially frozen [water-pack](#) contains both ice and water. An unfrozen [water-pack](#) contains only water.

Perform the all of the following tests on the [water-pack](#).

- **Shake test:** Shake the [water-pack](#) while holding the [water-pack](#) near the assessor's ear. If the sound of water sloshing in the [water-pack](#) is heard, then the [water-pack](#) fails the shake test.
- **Tilt test:** Tilt the [water-pack](#) back and forth while looking for the movement of air or water in the [water-pack](#). If the movement of air or water is observed, then the [water-pack](#) fails the tilt test.
- **Bulge test:** Water expands when it freezes. Examine the [water-pack](#) for localized bulging near the centreline of the [water-pack](#) when viewing the [water-pack](#) from the side. If localized bulging is not present, then the [water-pack](#) fails the bulge test.
- Classify the [water-pack](#) as follows:
 - If the [water-pack](#) passes all three tests, then the [water-pack](#) is fully frozen.
 - If the [water-pack](#) fails one or more tests, then the [water-pack](#) is partially frozen or unfrozen and fails the test.

Annex 4: Freeze protection classification symbols for refrigerators



Revision history (revisions since 12 August 2016)			
Date	Change summary	Reason for change	Approved
2 Feb. 2018	Definitions: Autonomy (for both freezer and refrigerator) are clarified.	Correction in terminology, no substantial technical change.	IG
2 Feb. 2018	Definitions: Cool down time added.	Addition required to clarify that two criteria must be met (i.e. acceptable temperatures and fully cooled mass).	IG
2 Feb. 2018	Definitions: Freeze protection classification clarified.	Correction in terminology to harmonize among E003 appliances, no substantial technical change.	IG
2 Feb. 2018	Definitions: Icepack storage capacity replaced with Water-pack storage capacity.	Correction in terminology, no substantial technical change.	IG
2 Feb. 2018	Definitions: Vaccine net storage clarified	Correction in terminology to harmonize among E003 appliances, no substantial technical change.	IG
2 Feb. 2018	Definition: User intervention changed.	References to absorption tasks removed.	IG
2 Feb. 2018	4.2.2 Refrigeration cycle specification refined.	Previous specification omitted key word, although no substantial technical change.	IG
2 Feb. 2018	4.2.8 Temperature control clarified.	Zone replaces load to assure any location designated for vaccine storage meets specification.	IG
2 Feb. 2018	4.9.1 Essential maintenance tools and supplies to be supplied.	Users are required to provide on-site maintenance and special tools/supplies must be provided.	IG
2 Feb. 2018	Annex 3: Fully frozen water-pack determination added.	Was missing in last version.	IG
24 Oct. 2019	Addition of bar code requirements	Supports more effective CCE management and tracking	IG
10 Sep 2020	Clause 3 (Terms and definitions) edited to amend and remove some PCM-related terms and definitions	Reflect changes to allowable use of PCM materials/packs as described the new draft PCM specification	Revised by: <i>Steve DeSandis</i> Approved by: <i>Isaac Gobina</i>

10 Sept 2020	Section 4.7 edited to include a definition of PCM	Reflect changes to allowable use of PCM materials/packs as described the new draft PCM specification	<i>Revised by:</i> <i>Steve DeSandis</i> <i>Approved by:</i> <i>Isaac Gobina</i>
15.09.2020	Terms & definition updated to include humidity-control	Reflect requirements included in the 2020 Humidity Control TPP	I. Gobina
15.09.2020	Clause 4.2.10 added on Humidity Control	Reflect requirements included in the 2020 Humidity Control TPP	I. Gobina