PQS Independent Type-testing Protocol

TITLE: Water-pack freezer: Solar direct drive without battery storage

Product verification protocol: E003/FZ03-VP.1
Applies to specification ref(s): E003/FZ03.1
Issue date: March 01, 2016
Date of last revision: 10 September 2020

Contents

1. Scope

This document describes the procedure for verifying the performance of water-pack freezer appliances powered by a solar electric system with no battery to support cooling system operation. These appliances are not suitable for storing vaccine.

An appliance that passes the relevant tests will be prequalified with a hot zone designation. If testing is carried out for more than one temperature zone, the full range of tests described in this document must be carried out for the optional temperature zone(s) selected.

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 and test methods.
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/FZ03: Performance specification: Water-pack freezer: Solar direct drive without battery storage.
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/E005/IP01: Water-packs for use as ice-packs, cool-packs and warm-packs.

3. Terms and definitions

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

Gross volume: The volume of the air space inside the internal compartment with the door or lid shut.

Hot zone: Hot zone appliances must operate at a steady +43°C ambient temperature.

In writing: means communication by letter, fax or email.

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

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

Moderate zone: Moderate zone appliances must operate at a steady +27°C ambient temperature.

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.

Reseller: A commercial entity, licensed to act on behalf of a legal manufacturer, and which carries appliance 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 water-pack freezer, expressed in kWh/m²/day.

Temperate zone: Temperate zone appliances must operate at a steady +32°C ambient temperature.

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 of fully frozen water-packs which remain at the end of the night phase of the water-pack freezing test.

Water-pack storage capacity: The maximum weight of fully frozen water-packs that can remain fully frozen at the end of testing over a five-day period.

4. Applicability

Type-testing will be carried out by an independent **ISO/IEC 17025** testing laboratory, accredited by WHO.

5. Type-testing procedure

5.1 Evidence of conformity assessment

Appliances must carry the CE mark, UL mark and/or equivalent internationally accepted evidence of conformity assessment.

5.2 Number of samples

The legal manufacturer or reseller must supply the testing laboratory with a full duplicate set of the Product Dossier already supplied to WHO in accordance with the requirements of specification clause 7. One sample of the appliance is required including English language versions of all required manuals and instructions. A compatible solar power system is not required. If more than one version of the appliance is available provide one sample of each version.

5.3 Test procedure

5.3.1 Solar power simulator

Refer to specification **E003/PV01** for solar power system specifications.

a. All performance tests use a direct current source to simulate a solar power array. To simulate a solar power array, use a programmable power supply or multiple power supplies connected to timers. The combined power supply and timer accuracy must be of ±0.1% or better. The power supply must simulate a solar radiation reference period by staging the power output with at least five output stages equal to 0.0 kW/m2, 0.05 kW/m2, 0.25 kW/m2, 0.35 kW/m2 and 0.45 kW/m2.
b. The solar radiation reference period for all appliances is 3.5 kWh/m^2/day designed to represent the average daily solar radiation received over a 24-hour period. All appliances must be tested at the solar radiation reference period of 3.5 kWh/m^2/day or less. The manufacturer must also specify the required solar power profile including:
    - Volts.
    - Amperes.
    - The daily run time in hours.
    - Suggested cool down time.
c. Amperage will be verified from solar module data sheets and will be based on solar module specifications as reported under standard test conditions (STC =1000 W/m^2 at 25˚C). The current will vary directly with the power supply output variables (e.g. use 45% of reported STC value for output stage 0.45 kW/m^2). The voltage may remain constant or may vary only if cooling system voltage varies with corresponding amperage.

d. Any additional solar radiation reference period can be simulated based on the table below[1]:

Day with 1.0 kWh/m²/day (IEC 62124)
5 hour at 200 W/m²
14 hours at 0 W/m²
Day with 3.5 kWh/m²/day (interpolated)
1 hour at 50 W/m²
2.5 hours at 250 W/m²
0.5 hours at 350 W/m²
4 hours at 450 W/m²
0.5 hours at 350 W/m²
2.5 hours at 250 W/m²
1 hour at 50 W/m²
Day with 6.0 kWh/m²/day (IEC 62124)
1 hour at 100 W/m²
3 hours at 500 W/m²
4 hours at 700 W/m²
3 hours at 500 W/m²
1 hour at 100 W/m²
12 hours at 0 W/m²

e. The simulated solar power supply must be set up, as described above, to model a typical solar radiation pattern experienced over an average day at the minimum solar radiation reference period. Note that in actual field conditions the power supply will be a solar array with similar power output to the manufacturer's specified power supply.

f. The power supply and runtime will be based on the solar radiation reference period the manufacturer specifies and this will be reported as the minimum solar resource for which the appliance is prequalified.

5.3.2 Test 1: Type examination

- **Step 1:** Unpack the appliance. Using the manufacturer's installation instructions only, set up the system components. Record the process and any problems encountered.
- **Step 2:** Check any defects or damage or any problem which make it difficult or impossible to test the appliance. If more than one sample, check for dissimilarities between samples of one model. If more than one model, check for similarities between different models.
- **Step 3:** Record any differences between the samples ordered and those received.
- **Step 4:** Tabulate the following information for each model submitted for examination. Obtain any additional supporting information required

[1] For example, if the appliance manufacturer specifies a solar array with operating characteristics of 10 amps DC (STC) operating at 15 Vdc with the minimum solar radiation reference period of 3.5 kWh/m2-day the simulated day would consist of a 12 hour night phase at 0 amps, then the 12 hour solar phase begins with 1 hour at 0.5 amps, then 2.5 hours at 2.5 amps, then 0.5 hours at 3.5 amps, then 4 hours at 4.5 amps, then 0.5 hours at 3.5 amps, then 2.5 hours at 2.5 amps and then 1 hour at 0.5 amps. The voltage remained constant at 15.0 Vdc.

in writing from the legal manufacturer or reseller and attach this information to the report:

Identification:

- Code (a unique identifier to be assigned by the testing laboratory).
- Model.
- Legal manufacturer or reseller.
- Appliance type (i.e. water-pack freezer, solar direct drive).
- Country of origin.
- Conformity assessment markings (e.g. CE mark).
- Temperature zone rating(s) against which the appliance is to be tested.

Performance characteristics:

- Temperature zone rating sticker conforms/does not conform to Annex 1 design specification clause 4.2.1.
- Refrigeration type conforms/does not conform to specification clause 4.2.2.
- Voltage conforms/does not conform to specification clause 4.2.3.
- Water-pack freezing compartment storage capacity conforms/does not conform to specification clause 4.2.5.
- Vaccine storage warning conforms/does not conform to specification clause 4.2.6.
- Thermostat type conforms/does not conform to specification clause 4.2.8.
- Thermometer conforms/does not conform to specification clause 4.2.9.
- Indicator light conforms/does not conform to specification clause 4.2.10.
- Power system requirements conform/does not conform to specification clause 4.2.12.
- Defrost switch conforms/does not conform to specification clause 4.2.13.
- Lock conforms/does not conform to specification clause 4.2.14.
- Corrosion resistance conforms/does not conform to specification clause 4.2.15.
- Electrical safety rating conforms/does not conform to specification clause 4.2.16.
- Markings conform/do not conform to specification clause 4.2.17.
- Labelling conforms/does not conform to specification clause 4.2.18.
- Electromagnetic compatibility conforms/does not conform to specification clause 4.2.19.

Environmental requirements:

- Ambient temperature range during transport and storage conforms/does not conform to specification clause 4.3.1.
- Ambient humidity range during transport, storage and use conforms/does not conform to specification clause 4.3.2.

Physical characteristics:

- Overall dimensions conform/do not conform to specification clause 4.4.1.
- Weight conforms/does not conform to specification clause 4.4.2.

Interface requirements:

- Electrical component compatibility conforms/does not conform to specification clause 4.5.1.
- Power switch conforms/does not conform to specification clause 4.5.2.

Human factors:
- General design of the appliance conforms/does not conform to specification clause 4.6.1.
- Control panel, indicator light and thermometer conforms/does not conform to specification clause 4.6.2.

Materials and construction:
- Record materials of all major visible components.
- Refrigerant conforms/does not conform to clause 4.7.1.
- Thermal insulation foaming agent conforms/does not conform to specification clause 4.7.2.
- Other restricted materials listed in clause 4.7.3 are/are not present.

PCM:

- PCM, if used, conforms/does not conform to the specification in clause 4.7.4. Manufacturer to provide documentation confirming compliance with **WHO/PQS/E005/PCMC0.1**– PCM specification for Phase-change material containers.

Physical data:
- Record major rectangular dimensions in centimetres (± 1.0 cm).
- Record weight in kilograms (± 0.25 kg).
- Record gross volume of freezer compartment(s) in litres.
- Record maximum water-pack capacity in kilograms.

Warranty:
- Warranty conforms/does not conform to specification clause 4.8.

Servicing provision:
- Essential spare part and user maintenance tools/supplies conforms/does not conform to specification 4.9.1.

Disposal and Recycling:
- Disposal and recycling information conforms/does not conform to specification 4.10.

Instructions:
- Instructions conform/do not conform to specification clause 4.11.

- **Step 5:** Take a three-quarter view digital photograph of the appliance with the door open. Take additional photographs showing all external surfaces of the appliance, 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 or identified weaknesses of the appliance. High resolution digital images should be provided for attachment to the PQS report.

Acceptance criteria: Inspection indicates full conformity with all major specification requirements. System setup must be straightforward and trouble-free.

5.3.3 Test temperatures

All appliances are to be tested to hot zone temperatures and per Annex 1-General Test Conditions. Record test room ambient and internal cabinet temperatures for at least 48 hours prior to all tests. The specific tests listed below apply equally to moderate zone, temperate zone and hot zone appliances. Relevant test chamber temperatures are given in the following format M:<XX>°C for moderate zone; T:<XX>°C for temperate zone and H:<XX>°C for hot zone.

5.3.4 Test 2: Cool-down and power consumption

- **Power:** Simulated solar power as clause 5.3.1.
- **Step 1:** Set the test chamber temperature to H:+43°C (optional M:+27ºC, T:+32°C), and leave for 48 hours with the appliance empty, the lid or door open and the power supply switched off.
- **Step 2:** Close the lid or door of the appliance, switch it on and allow to stabilize. Record freezer compartment temperatures every minute and measure electricity consumption.
- **Step 3:** After stability continue the test for at least one complete solar cycle. Measure electricity consumption and the cooling system duty cycle over the same test duration and report energy consumption in kWh/day, the percentage on-time during the 12-hour solar phase and graphically display on/off cycles. Report the solar power profile (see 5.3.1).

Acceptance criterion: Stabilized internal temperatures maintained below 0°C in the water-pack freezing compartment achieved within the 12-hour solar phase. Water-pack freezing compartment excursions above 0°C are permitted during the 12-hour night phase and first three hours of the 12-hour solar phase of the simulated solar power cycle. No standard set for the cool-down time or energy consumption but report the total hours to cool down, energy consumption in kWh/day, the percentage on-time during the 12-hour solar phase and graphically display on/off cycles.

Rejection criterion: Failure to stabilize within the required temperature ranges. Halt the test if the temperature does not stabilize within the period specified by the manufacturer, plus one additional day.

5.3.5 Test 3: Stable running and power consumption

- **Power:** Simulated solar power as clause 5.3.1.
- **Step 1:** When the internal temperature is stabilized at the end of Test 2, ensure that the water-pack freezing compartment is empty.
- **Step 2:** With temperature stabilization achieved, record temperatures every minute for at least one complete solar cycle. Measure electricity consumption and the cooling system duty cycle over the same test duration and report energy consumption in kWh/day, the percentage on-time over the 12-hour solar phase and graphically display on/off cycles. Report the solar power profile (see clause 5.3.1).

Acceptance criteria: Stabilized internal temperatures maintained below 0°C in the water-pack freezing compartment within the 12-hour solar phase. Water-pack freezing compartment excursions above 0°C are permitted during the 12-hour night phase and first three hours of the 12-hour solar phase of the simulated solar power cycle. No standard set for power consumption but report the energy consumption in kWh/day, the percentage on-time during the 12 hour solar phase and graphically display on/off cycles.

Rejection criterion: Failure to meet one or more of the acceptance criteria.

5.3.6 Test 4: Daily water-pack freezing capacity and power consumption

- **Power:** Simulated solar power as Clause 5.3.1.
- **Step 1:** Continue the Test 3 conditions. DO NOT adjust the freezer thermostat.
- **Step 2:** Label and stabilize water-packs at M:+27ºC, T:+32°C, H:+43°C.
- **Step 3:** At the end of the 12-hour night-time phase of a 24-hour cycle load a minimum of 1.6 kg of water-packs and not less than 2.4 kg per 50 litres of gross freezer volume of water-packs into the freezer compartment in accordance with user instructions which includes any rack or structure provided for holding water-packs. The process [2] to achieve the maximum freezing capacity must be stated in the user instructions.
- **Step 4:** Record compartment temperatures every minute for the following 24 hours. Measure electricity consumption and the cooling system duty cycle over the same duration. Report energy consumption in kWh/day, percentage on-time over the 12-hour solar phase and graphically display on/off cycles.
- **Step 5:** At the end of the next 12-hour night phase remove all water-packs and determine which are fully frozen and which are not fully frozen per instructions in Annex 1 – Fully frozen water-pack determination. Record each water-pack location and condition (i.e. fully frozen or not fully frozen). Immediately return frozen packs to the freezer. Note: It must be possible to remove frozen water-packs without any undue force or delay. Defrosting the freezer to enable removal is not acceptable.
- **Step 6:** Repeat steps 3 to 5 loading more stabilized water-packs in accordance with user instructions up to the point when the total net weight of fully frozen water-packs has not increased since the previous cycle or until the freezing compartment is full. The number of fully frozen water-packs at the end of each night-time phase are to be reported. This is the appliance's daily water-pack freezing capacity.

[2] Manufacturer should state the number of water packs to be loaded on Day 1, Day 2, Day 3 etc. to give the maximum daily freezing capacity.

Acceptance criteria: For freezers of less than 50 litres of gross freezer volume a minimum of 1.6 kg of fully frozen water-packs must remain fully frozen at the end of the 12-hour night phase. For freezers with at least 50 litres of gross freezer volume a minimum of 2.4 kg of fully frozen water-packs per 50 litres of gross freezer volume must remain fully frozen at the end of the 12-hour night phase. No standard set for power consumption but report the energy consumption in kWh/day, the percentage on-time during the 12 hour solar phase and graphically display on/off cycles.

Rejection criterion: Failure to meet one or more of the acceptance criteria.

5.3.7 Test 5: Day/night, frozen water-pack storage, water pack freezing and power consumption

- **Power:** Simulated solar power as clause 5.3.1.
- **Step 1:** Incorporating the result from Test 4, allow the appliance to stabilize for a further 24 hours only with the freezing compartment full of completely frozen packs equivalent to the final result from Test 4.
- **Step 2:** For further loading (see Step 6), label and stabilize additional water-packs at M: +27ºC, T: +32°C, H: +43°C.
- **Step 3:** Beginning with a 12 hour day phase of a 24 hour solar cycle hold the temperature of the test chamber to M:+27ºC, T:+32°C, H:+43°C, for a further 12 hours. Then lower the temperature to M:+10ºC, T:+15ºC, H:+25ºC over a 3 hour period. Hold at M:+10ºC, T:+15ºC, H:+25ºC for a further 9 hours. Next raise the ambient temperature to M:+27ºC, T:+32°C, H:+43°C over a further 3 hour period. Hold at M:+27ºC, T:+32ºC, H:+43ºC for a further 9 hours. Repeat this simulated day-night cycle for five complete 24-hour solar cycles in total.
- **Step 4:** At the end of the first 12-hour night-time phase of a 24-hour solar cycle remove a minimum of 1.6 kg of water-packs and not less than 2.4 kg per 50 litres of gross freezer volume of water-packs from the freezer compartment. (These packs will not be returned to the freezer.)
- **Step 5:** Record compartment temperatures every minute for the whole test. Measure electricity consumption and the cooling system duty cycle over the same test duration and report energy consumption in kWh/day, the percentage on-time over the 12-hour solar phase and graphically display on/off cycles.
- **Step 6:** At the end of the 12-hour day phase load water-packs which have been stabilized in accordance with Step 2. This loading replaces the water-packs removed in Step 4.
- **Step 7:** At the end of the next night phase, record each water-pack location and condition (i.e. fully frozen or not fully frozen) per instructions in Annex 1- Fully frozen water-pack determination. Except for packs which are to be removed in Step 4, return water packs to exact positions without delay[3].

[3] Note: It must be possible to remove frozen water-packs without any undue force or delay. Defrosting the freezer to enable removal is not acceptable.

- **Step 8:** Repeat steps 3 to 7 until five complete day-night cycles have been completed. If possible, packs removed in each repetition of Step 4 must include packs by rotation not previously removed. Record and report the maximum number of fully frozen water-packs that can remain fully frozen at the end of every night-time phase.

Acceptance criterion: No acceptance criteria: The number of fully frozen and non-fully frozen packs at the end of each night-time phase to be reported. No standard set for power consumption but report the energy consumption in kWh/day, the percentage on-time during the 12 hour solar phase and graphically display on/off cycles.

5.3.8 Test 6: Autonomy (freezer) and power consumption

- **Power:** Simulated solar power as clause 5.3.1.
- **Step 1:** Freezer to be set up as at the end of Test 4 – a freezer compartment with fully frozen packs full to its Test 4 freezing capacity. Allow to stabilize for at least 48 hours.
- **Step 2:** Reduce the output power supply at the beginning of the 12-hour solar phase. The reduced power output power supply must provide the same voltage as specified by the manufacturer, but no more than 5% of the maximum ampere input specified by the manufacturer based on the minimum solar radiation reference period.
- **Step 3:** At the end of each 12-hour night phase remove water-packs one at a time and determine which are fully frozen and which are not fully frozen per instructions in Annex 1: Fully frozen water-pack determination. Record each water-pack location and condition (i.e. fully frozen or not fully frozen) and return this back to the freezing compartment without delay. At the end of each night phase visually inspect the level of frozen packs and record. Halt the test when the load of frozen water-packs falls below the minimum daily water-pack freezing requirement (i.e. a minimum of 1.6 kg of water-packs and not less than 2.4 kg per 50 litres of gross freezer volume of frozen water-packs remaining). Round down to nearest half day increment to report the freezer autonomy period. Report autonomy in increments of half days.

Acceptance criterion: Minimum autonomy is overnight (0.5 day) at the minimum solar radiation reference period. Additional autonomy will be reported in half day increments (e.g. report autonomy (freezer) results as "<XX> kg of fully frozen water-packs remains available for an autonomy period of <X.X> days under hot zone temperatures and low solar radiation conditions). No standard set for power consumption but report the energy consumption in kWh/day, the percentage on-time during the 12 hour solar phase and graphically display on/off cycles.

Rejection criterion: Failure to meet the minimum autonomy period of one overnight period (0.5 days) at test conditions.

5.4 Test criteria for qualification

A final report must be issued after all testing is complete. The report of the tests must contain the following data and analyses:

- **Summary:** Conclusions and recommendations, including confirmation of hot zone application at solar radiation reference period of 3.5 kWh/m²/day and optionally, other temperature zone(s) and/or other solar radiation reference period(s) for which the appliance is suitable.
- **Test 1:** Comments on samples received, tabulated data on the type-examination test and relevant photographs.
- **Test 2:** Results of cool-down test, including temperatures, electricity consumption, on-time and cooling system on/off cycles graphically displayed
- **Test 3:** Results of stable running and consumption test, including temperatures, electricity consumption, on-time and cooling system on/off cycles graphically displayed.
- **Test 4:** Results of daily water-pack freezing test, including temperatures, electricity consumption, on-time and cooling system on/off cycles graphically displayed.
- **Test 5:** Results of storage of frozen water-packs test, including temperatures, electricity consumption, on-time and cooling system on/off cycles graphically displayed.
- **Test 6:** Results of autonomy test, including temperatures, electricity consumption, on-time and cooling system on/off cycles graphically displayed.

Annexes: Description of the test apparatus. Test chamber temperature records. Copy of reference thermometer calibration certificate(s). Diagrams showing the location and identification codes for temperature sensors. Solar power system specifications used in testing. Additional supporting documentation requested and received from the legal manufacturer or reseller during the course of the type-testing.

6. Quality control checklist

6.1 Quality control standards

All testing and reporting must be carried out in accordance with the requirements of **ISO 17025**.

6.2 Quality control checklist

An on-site inspection of the manufacturing plant is not required.

6.3 Quality control evaluation

Not required.

7. Prequalification evaluation

An appliance will qualify for inclusion on the register of PQS prequalified equipment in accordance with WHO procedures provided the final report indicates full conformity with the requirements of specification **E003/FZ03.0.**

8. Modified products

The legal manufacturer or reseller must notify WHO in writing of any changes which affect the performance of the appliance. WHO will carry out a desk evaluation of the reported change(s). If any change is deemed adversely to affect the performance of the appliance, WHO may request full or partial re-verification based on the test procedures described in this document.

Annex 1 – General test conditions

The following conditions are applicable to all SDD water-pack freezer tests.

Test conditions:

- Carry out tests in a test chamber in which temperatures can be controlled to ±1ºC and humidity within the range of 45% to 75% unless otherwise stated below. Measure test chamber temperatures in accordance with **IEC 62552**, clause 8.2.
- Maximum test chamber temperatures of M:+27ºC, T:+32ºC and H:+43ºC are required for the tests.
- Temperatures within the appliance must be continuously monitored to an accuracy of ±0.5ºC without the presence of the sensors influencing the test in any way. Thermocouples that are sealed within the appliance are most commonly used. Up to 15 simultaneous temperature measurements may be required for a single appliance (e.g. ambient and freezer locations). The suggested temperature sensor locations are shown in Annex 2. See Annex 3 for temperature sensor specifications.
- Position the test appliance in the test chamber with its back face 50 mm clear of one of the chamber walls. Ensure that it is accurately levelled.

Stabilization times:

Before measuring the performance of an appliance under normal running conditions, temperature conditions inside the appliance must be stable. This is normally assumed to have occurred when either:

- The thermostat has been cycling for 24 hours, or
- The temperature at each of corresponding points during successive operating cycles varies by less than ±1ºC and there is no marked trend away from the mean temperature at that point over 24 hours.

Recording temperatures:

- Test appliances, either loaded or empty, as described above in the verification protocol.
- Take temperature readings once per minute.

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 a 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.

Sensor placement:

- Place sensors at the centre of the load compartment and at other positions which are likely to experience extremes of temperature. Such positions might be near door seals, or where air circulation is restricted by the appliance design – see the Annex 2 sensor position diagrams and note.
- Fix the sensors in position so that they cannot be displaced during the course of the tests. Sensors may be fixed in position using thin rigid wire, tape or similar materials which do not affect the thermal performance of the appliance.
- After initial setup, do not alter the position of sensors during subsequent tests.
- Where sensors are located in the water-pack storage compartment place them within the volume designated by the manufacturer for water-pack storage.
- Where storage baskets are supplied with the appliance, fix sensors within the volume(s) defined by the internal faces of the basket(s).
- Monitor all sensors so that an overall picture of the temperature distribution can be obtained.

Where applicable, the following points should also be monitored:

- Surface temperature of evaporator plates.
- Condenser fins or outer skin temperatures.

Water-packs:

Tests which require water-packs must use 0.3, 0.4 or 0.6 litre water-packs conforming to PQS specification **E005/IP01.**

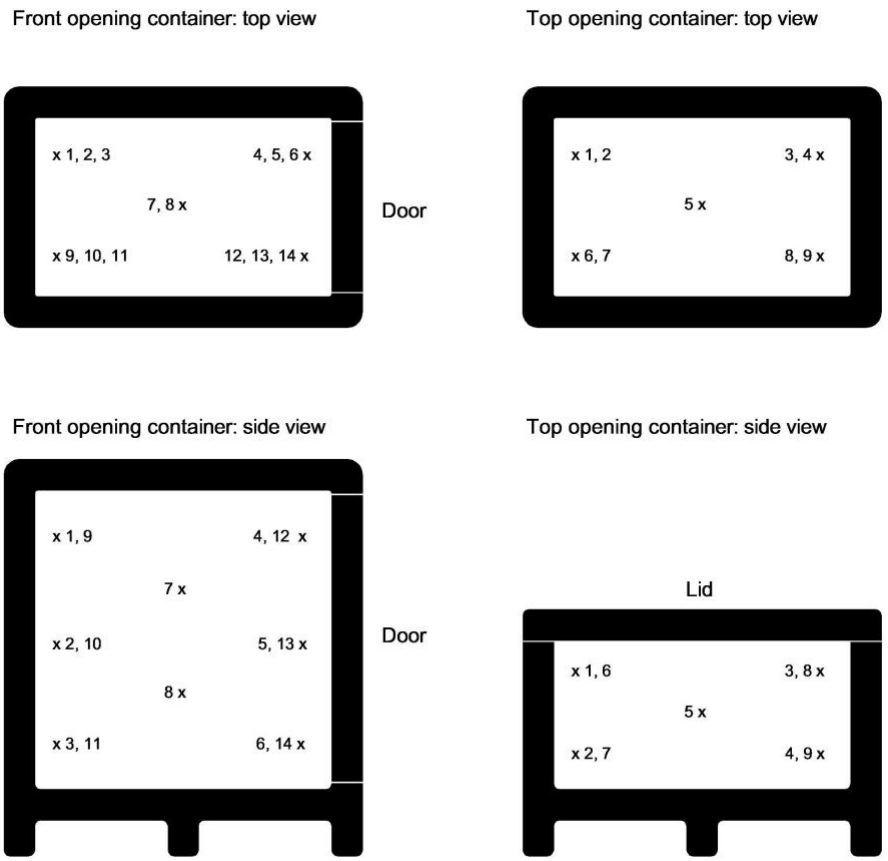
Dual compressor or multi-stage cooling appliances:

Both compressors or all cooling stages should be switched on during all tests.

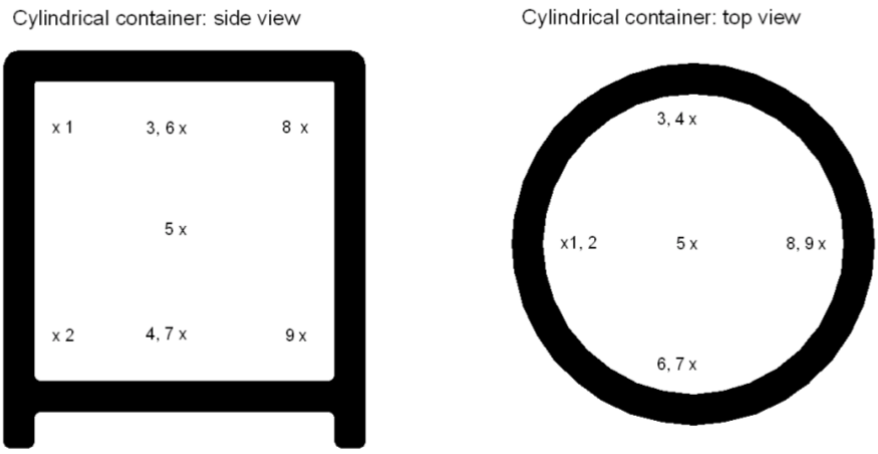
Multi-function, multi-voltage and multi-fuel appliances:

Testing of multi-function, multi-voltage and multi-fuel appliances will be lengthy and costly, so a decision on which options should be tested will be made by WHO PQS Secretariat on a case by case basis.

Annex 2 – Temperature sensor positions: Rectangular and square compartments



Cylindrical compartments



Notes:

Top opening sensor configuration applies to appliances not exceeding 600mm internal depth. Use the front opening configuration for deeper appliances.

Approximate sensor positions are indicated by the figures. Except for sensors placed centrally in a compartment, the centre of sensors should be placed 50 ±10 mm away from the lining of the water-pack freezing compartment.

Annex 3 – Temperature sensor specification

Complying with **IEC 62552**, clause 8.7.1. Probe, accurate to ±0.5°C, inserted into brass or tin-covered copper mass of 25 g ± 5 % and of minimum external area (diameter = height = about 15.2 mm).

Revision history			
Date	Change summary	Reason for change	Approved
25.09.2018	Clause 3 (Terms and definitions) PCM definition added.	Reflect change to allowance of water-based and PCM-based buffers	I. Gobina
25.09.2018	Bullet on PCM conformity with relevant product specification and compliance with PCM materials specification added to Clause 5.3.2 (Type examination)	Reflects change to allowance of PCM-based buffer materials as per product specification.	I.Gobina
10.09.2020	Formatting and minor edits or style.		I.Gobina