TITLE: Water-pack freezer: absorption cycle

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1. Scope

This document describes the procedure for verifying the performance of absorption cycle water-pack freezers. A product that passes the relevant tests will be prequalified with a specific temperature zone designation. Three temperature zones are described: moderate zone, temperate zone and hot zone; the scope of each category is defined in clause 3.

Manufacturers can offer a product for testing at one or more of the three temperature zones. If testing is carried out for more than one zone, the full range of tests described in this document must be carried out for the hottest temperature zone selected. When testing for the selected lower temperature zones, the following tests may optionally be omitted: testing dual fuel units under electrical power and holdover time.

2. Normative references

BS2869: 2017: Specification for fuel oils for agricultural, domestic and industrial engines and boilers.
DIN 8985: 1983-05: Testing the surfaces of installed refrigerators and freezers.
IEC 60335-2-24: 2020 - Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers.
IEC 62552-1: 2015: Household refrigerating appliances – Characteristics and test methods.
ISO/IEC 17025: 2017: General requirements for the competence of testing and calibration laboratories.
WHO/PQS/E003/FZ02.2: Performance Specification: Water-pack freezer: absorption cycle.

3. Terms and definitions

Holdover time: The time in hours during which the warmest point in the water-pack freezing compartment of the freezer remain below -3°C, at the maximum ambient temperature of the temperature zone for which the appliance is rated, after the fuel supply has been disconnected.
Hot zone: Hot zone appliances must operate at a steady +43°C ambient temperature and over a+43°C/+25°C day/night cycling temperature range.
In writing: means 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 his own name, regardless of whether these operations are carried out by that person himself or on his behalf by a third party.
Manufacturer's gross volume: The manufacturer's stated gross volume or, for purposes of comparison, the internal free volume, including the space occupied by the freezing compartment, and the volume occupied by shelves, but excluding the space taken by the ice-lining or other type of thermal storage, if present.
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.
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.
Temperate zone: Temperate zone appliances must operate at a steady +32°C ambient temperature and over a+32°C/+15°C day/night cycling temperature range.
Water-pack: Flat plastic container, filled with water, conforming to specification **E005/IP01**.
Water-pack freezing capacity: The maximum weight of water-packs which can be frozen, in one batch, during a 24-hour freezing cycle. During this period the temperature of the water-pack freezing compartment must remain below -3ºC, except during the actual freezing process after unfrozen water-packs have been loaded.

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

Products 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 product is required. If more than one version of the product is available (for example, for different climate zones), provide one sample of each version. For products that are fitted with optional electrical power, ensure that the voltage and frequency rating of the sample(s) is suitable for the country where the test laboratory is located[1].

1 If there is any doubt that the performance of the product will vary under the other nominal voltage/frequency combinations supplied by the manufacturer, he must be asked to comment in writing.

5.3 Test procedure

5.3.1 Test 1: Type examination

- **Step 1:** Unpack the product. Using the manufacturer's installation instructions only, set up the system components. Record the process and any problems encountered.
- **Step 2:** Check all samples for similarities between different models[2], dissimilarities between samples of one model, any defects or damage or any problem which make it difficult or impossible to test the appliance.
- **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 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;
  - Product type (i.e. vaccine refrigerators or combination unit);
  - Country of origin;
  - Conformity assessment markings (e.g. CE mark).

  Performance characteristics:
  - Temperature zone rating sticker conforms/does not conform to Annex 1 design (specification clause 4.2.1).
  - Cycle type conforms/does not conform to specification clause 4.2.2. Report fuel options.
  - Water-pack freezing compartment capacity conforms/does not conform to specification clause 4.2.3.
  - Temperature control system conforms/does not conform to specification clause 4.2.4.
  - Thermostat/flame control device conforms/does not conform to specification clause 4.2.5.
  - Flame failure device (where applicable) conforms/does not conform to specification clause 4.2.6.
  - Lock conforms/does not conform to specification clause 4.2.8.
  - Corrosion resistance conforms/does not conform to specification clause 4.2.11.
  - Thermometer (if fitted) conforms/does not conform to specification clause 4.2.12.

[2] The purpose of this inspection is to establish whether products offered by competing companies are re-badged versions of an otherwise identical product.

- For products with relevant electrical components only: Electrical safety rating conforms/does not conform to specification clause 4.2.13.
- Markings conform/do not conform to specification clause 4.2.14.
- Vaccine storage advice conforms/does not conform to specification clause 4.2.15.

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:

- Power lead (if fitted) conforms/does not conform to specification clause 4.5.1.

Human factors:

- General design of the product conforms/does not conform to specification clause 4.6.1.
- Control panel 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 internal volume of freezer compartment(s) in litres.
- Record maximum water-pack capacity in kilograms.
- *Kerosene units only:* Record fuel tank capacity.

Warranty

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

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. A high-resolution digital image in jpeg format should be provided for attachment to the PQS report. Take any other photographs needed to illustrate features of the product in the report.

Acceptance criteria: Inspection indicates full conformity with all major specification requirements.

5.3.2 Test temperatures

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.

5.3.3 Kerosene quality

Kerosene-fuelled appliances should be tested using kerosene as specified in specification **E003/FZ02** – Annex 3.

5.3.4 Testing dual fuel units under electrical power

WHO and the product manufacturer will agree whether tests should be carried out under electrical power. If electrical power tests are carried out these must be done first. The test cycle should then be repeated with gas or kerosene. Report the test results under both power sources as described in clause 5.4.

5.3.5 Test 2: Water-pack freezing capacity

- **Step 1:** Set the test chamber temperature to M:+27ºC, T:+32°C, H:+43°C and leave for 48 hours with the appliance empty, the lid or door open and the power supply switched off.
- **Step 2:** Stabilize water-packs at M:+27ºC, T:+32°C, H:+43°C.
- **Step 3:** Close the lid or door of the appliance, switch it on and leave it to stabilize with the thermostat/flame control on its maximum setting.
- **Step 4:** After stabilization, load the freezing compartment or designated freezing zone of the appliance with water-packs. The number of water- packs should be the maximum recommended by the manufacturer. Alternatively, the number may be based on the test laboratory's initial estimate, subject to a minimum of four 0.6 litre water-packs per 50 litre gross volume. Load the water-packs in a row and with the edges perpendicular to the evaporator surface, or in accordance with the manufacturer's recommendations. Install thermocouples, centred as uniformly as

possible between the loaded water-packs. The minimum distance between a thermocouple and the lid/door, wall or evaporator should be 30mm.

- **Step 5:** Record water-pack load temperatures every minute for the following 24 hours.
- **Step 6:** At the end of the test period check that the water-packs are frozen solid. Remove the frozen water-packs.
- **Step 7:** Repeat steps 4 to 6 introducing larger loads of stabilized water- packs up to the point when one or more of the water-packs does not fullyfreeze within the 24-hour period, or the compartment/designated zone is full.
- **Step 8:** Record the maximum weight of water-packs that can be frozen within 24 hours. This is the appliance's 'water-pack freezing capacity'. Record fuel consumption for each 24-hour test (litres/day for kerosene; kg/day for gas, kWh/day for electricity).

Acceptance criterion: Not less than 2.4 kg of water-packs must be frozen per 24 hours. Report the maximum 24-hour fuel consumption.

1.1.2 Test 3: Water-pack storage capacity

- **Flame/thermostat setting:** As Test 2.
- **Step 1:** Continue the Test 2 conditions, with the freezing compartment or designated freezing zone loaded with the maximum weight of frozen water- packs established in that test.
- **Step 2:** Using a test chamber, fully freeze a test batch of 0.6 litre water- packs and stabilize them at -3ºC.
- **Step 3:** Load the storage compartment or designated storage zone with a minimum of ten of these fully frozen water-packs.
- **Step 4:** Record water-pack temperatures every minute for the following 24 hours.
- **Step 5:** At the end of the test period, check that all water-packs in the freezing compartment or designated freezing zone, and all water-packs in the storage compartment of designated storage zone remain fully frozen.
- **Step 6:** Increase the load of -3°C frozen water-packs in the storage compartment or designated storage zone by a suitable amount.
- **Step 7:** Repeat steps 3 to 7 until one or more of the water-packs fails to remain frozen at the end of the 24-hour cycle or the storage compartment/designated storage zone is full. Establish the maximum total load (freezing compartment/zone + storage compartment/zone that remains fully frozen at the end of the 24-hour test cycle. This is the appliance's 'water-pack storage capacity'. Record fuel consumption for each 24-hour test (litres/day for kerosene; kg/day for gas, kWh/day for electricity).

Acceptance criteria: The freezer should accommodate a minimum of 8.4 kg of frozen water-packs. Report the maximum 24-hour fuel consumption.

5.3.6 Test 4: Holdover time

- **Flame/thermostat setting:** As Test 2.
- **Step 1:** Set the test chamber temperature to M:+27ºC, T:+32°C, H:+43°C. Ensure that the appliance is empty.
- **Step 2:** Switch the appliance on and allow the internal temperature to stabilize for 48 hours.
- Step 3:
  Electrical units: Turn off the power supply when the temperature has stabilized.
  Gas-fuelled units: Switch off the fuel supply at the moment the thermostat triggers an ON phase.
  Kerosene-fuelled units: Turn off the flame when the temperature has stabilized.
- **Step 4:** Monitor the temperature of the empty freezer compartment at one-minute intervals. At the moment when the warmest point in the compartment exceeds -3°C, record the elapsed time since switch off.

Acceptance criterion: No standard set. Performance data will be reported.

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 the temperature zone(s) for which the product is suitable.
- **Test 1:** Comments on samples received, tabulated data on the type- examination test and relevant photographs.
- **Test 2:** Results of water-pack freezing capacity test, including temperature graphs and fuel consumption.
- **Test 3:** Results of water-pack storage capacity test, including temperature graphs and fuel consumption.
- **Test 4:** Results of holdover time test, including temperature graphs.
- **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, clearly distinguishing between sensors measuring vaccine, water-pack, freezer and evaporator temperatures. 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** or later edition.

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

A product will qualify for inclusion on the register of PQS prequalified absorption freezer equipment in accordance with WHO procedures provided the final report indicates full conformity with the requirements of specification **E003/FZ02**.

8. Modified products

The legal manufacturer or reseller must notify WHO in writing of any changes which affect the performance of the product. WHO will carry out a desk evaluation of the reported change(s). If any change is deemed adversely to affect the performance of the product, 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 refrigerator and 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.
- Minimum test chamber temperatures down to -15°C may be required for the minimum ambient temperature rating test. The actual minimum required for a specific appliance should be discussed with the product manufacturer before the test commences.
- 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. 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 a refrigerator or freezer 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.

Vaccine storage capacity measurement:

- Measure vaccine storage capacity using cardboard boxes, plastic foam or wooden blocks, 100 x 100 x 100 mm and 100 x 100 x 50 mm.
- Fill the appliance up to the maximum loading line recommended by the manufacturer.
- Where baskets and shelves are supplied, these should be used to hold the dummy load. Do not place any boxes outside the zone designated by the manufacturer for vaccine storage.
- Do not place the dummy load in the fast freeze compartments of vaccine freezers.

Recording temperatures:

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

Sensor placement:

- Place sensors at the centre of the vaccine 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 vaccine storage compartment place them within the volume designated by the manufacturer for vaccine storage.
- Where vaccine 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;
- Flue temperature;
- Condenser fins or outer skin temperatures.

Dummy vaccine load:

Make up a dummy vaccine load[3] using partially filled water-packs.

- Measure the chosen water-packs to establish their nominal unit volume in litres (length x width x thickness in cm/1000).
- Select the number of empty water-packs required to build a dummy load whose nominal volume is equal to the measured vaccine storage capacity in litres divided by five, ± 5%.
- Partially fill the water-packs with equal volumes of water so that the mass of the load is equal to the nominal load volume x 0.4 kg (0.4 kg per litre).

[3] The dummy load described below is intended to approximate the minimum vaccine load in a well-managed refrigerator holding a 25% safety stock.

Pre-condition the dummy load at +8°C and place in the appliance as follows so that it does not interfere with the sensor positions already established:

Front-opening appliances:

- Stack the partially filled water-packs evenly on the shelves designated for vaccine storage.

Top-opening refrigerators:

- Stack the partially filled water-packs evenly on the bottom of baskets supplied for vaccine storage.
- If baskets are not required to keep vaccine away from the base and walls of the appliance, stack the partially filled water-packs evenly on the base of the appliance.

Top-opening freezers:

- Stack the partially filled water-packs evenly on the base of the appliance.

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 units:
Both compressors should be switched on during all tests.

Multi-fuel and multi-function appliances:

- Multi-fuel equipment (typically absorption refrigerators or freezers) will be lengthy and costly to test, so a decision on which options should be tested will be made by WHO on a case by case basis.
- In the case of appliances which can be run either as a freezer or as a refrigerator, the first set of tests should test the refrigerator function and the second set should test the freezer function.

Annex 2 – Temperature sensor positions

Approximate sensor positions are indicated by the figures. Except for sensors placed centrally in a compartment, the centre of sensors should be placed 50±5 mm away from the lining of the water-pack freezing compartment or vaccine storage compartment. If baskets are used for vaccine storage, the sensors should be located inside the basket(s) but not touching the basket material.

Figure 1: Chest freezers

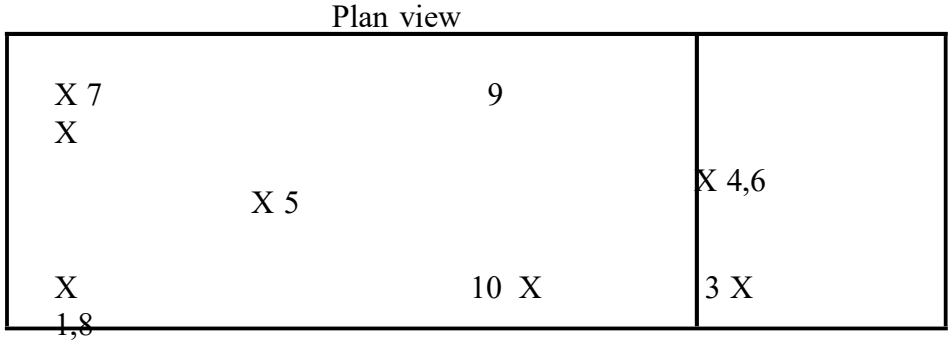


Figure 2: Chest freezers

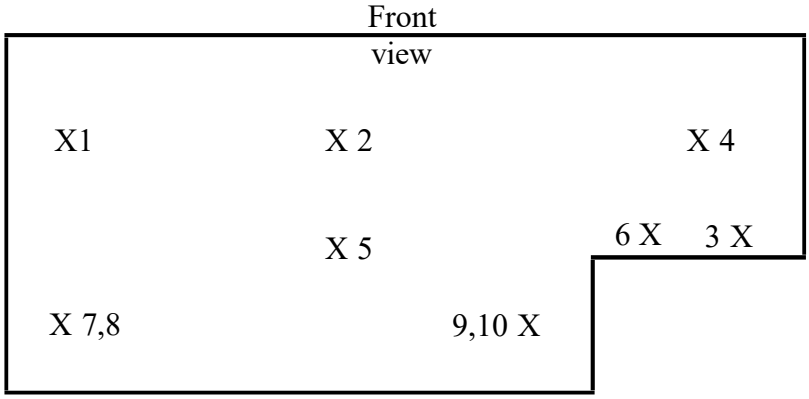
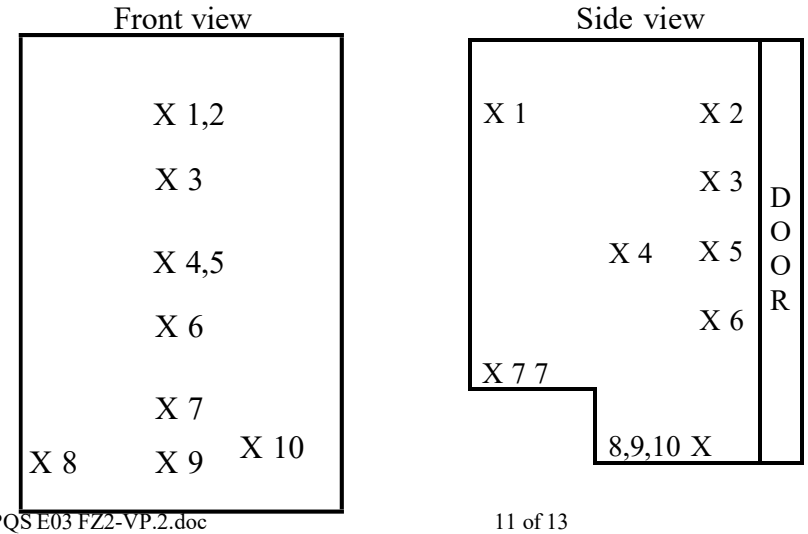


Figure 3: Water-pack fast freezers



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
23.05.2007	General edit	Final revisions to PQS format.	UK
31.05.2007	SMc comments incorporated. 5.3.1: Kerosene tank capacity check added. Temperature control setting for all		UK
02.08.2007	Clause 5.3.3 added.	Following consultation with industry.	UK
06.07.2010	Scope: Note added. 'Icepack' changed to 'water-pack'. 2: Normative references updated. IEC 60335 added. 3: Holdover clarified, temperature changed to -3°C. Water-pack definition clarified. Water-pack freezing capacity. Temperature changed to -3°C and clarification added. 5.2: Reference to optional electrical power added. 5.3.1: Aligned with revised spec. New clauses 4.2.13 and 4.5.1 added. 5.3.4: Clause added. 5.3.5: Step 4: no. of water-packs corrected; clarification added. Step 8: Wording amended to include electrical power consumption. Minor clarification of units. 5.3.6 – Step 8: Wording amended to include electrical power consumption. Minor clarification of units. Steps 4, 6 & 7 amended. 5.3.6: Test re-drafted. 5.3.7- Step 3: Electric units added. Acceptance criterion temperature changed to -3°C. 7. Typo corrected. Cross references to	Response to comments from manufacturers, testing laboratories and others.	
21.10. 2018	Clause 3 (Terms and definitions) PCM definition added.	Reflect change to allowance of water-based and PCM-based buffers	I. Gobina

21.10. 2018	Bullet on PCM conformity with relevant product specification and compliance with PCM materials specification added to Clause 5.3.1 (Type examination)	Reflects change to allowance of PCM-based buffer materials as per product specification.	I.Gobina
10.09. 2020	Formatting and minor edits for style		I. Gobina