TITLE: Solar power system for compression-cycle vaccine refrigerator or combined refrigerator and water-pack freezer – on-site checklists for completed installations.

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1. Scope:

This document sets out the requirements for the procurement, installation and commissioning of solar powered vaccine refrigerator installations on one or more sites.

Two alternative systems are covered by this protocol. **Type 1** systems use a solar array to charge an electrical storage battery pack, which then powers refrigeration equipment complying with specification **E003/RF04**. **Type 2** systems use a solar array directly to power the refrigerator compressor. Direct drive refrigeration equipment complying with specification **E003/RF05** is entirely battery free. Direct drive refrigeration complying with specification **E003/RF06** uses an integrated battery to power ancillary equipment such as fans, instrumentation and control. This battery is charged from the solar array.

The procurement agency should complete Annex 1, and issue the document together with a copy of specification **E003/PV01.2** to one or more qualified suppliers as the basis for obtaining tender offers. A copy of the Annex 2 checklist should subsequently be completed by the installation technician at the time of commisssioning and handover and a copy of the Annex 3 checklist should be completed by the user at the end of the first 30 days of operation.

It is intended that the partly completed **E003/PV01-VP2.2** and any other supporting documents that the procurement agency considers necessary, together with the successful tenderer's priced offer, should form the basis for a contractual agreement between the parties for the supply, installation and commissioning of one or more installation(s).

2. Normative references:

Toma, H. and Markvart, T. *Solar Autonomy Calculation Tool*, University of Southampton, UK 2009.
WHO/PQS/E003/PV01.2: *Solar power system for compression-cycle vaccine refrigerator or combined refrigerator and water-pack freezer.*
WHO/PQS/E003/RF04.2: *Refrigerator or combined refrigerator and water-pack freezer: compression-cycle. For solar powered rechargeable battery storage.*
WHO/PQS/E003/RF05.2: *Refrigerator or combined refrigerator and water-pack freezer: compression-cycle. Solar direct drive without battery storage.*
WHO/PQS/E003/RF06.1: *Refrigerator or combined refrigerator and water-pack freezer: compression-cycle. Solar direct drive with ancillary rechargeable battery.*

3. Terms and definitions:

Installation: The solar power system specified in this document connected to a refrigerator, or combined refrigerator and water-pack freezer, complying with specification **E003/RF04**, **E003/RF05** or **E003/RF06.**
Installation technician: The person who installs the solar power system and associated refrigerator on behalf of the procurement agency.
Procurement Agency: The organization which purchases the equipment covered by this specification and which provides the qualified supplier with details of the installation site(s).
Qualified Supplier: A qualified supplier must:

- Supply a coherent, correctly sized system where the settings of all the components have been adjusted for optimum performance at the installation site.
- Have installed and supported at least ten photovoltaic systems in a developing country or countries for at least two years (detailed references, including donors, locations and contacts, must be provided).
- Have the capacity and financial resources to provide long term support to the systems in the country of destination.
- Offer one or more refrigerators or combined refrigerator and water-pack freezers complying with PQS standards **E003/RF04** and/or **E003/RF05** and/or **E003/RF06** and which are currently pre-qualified by WHO.

User: The person responsible for the day to day operation and temperature monitoring of the installation.

4. Applicability:

The Annex 1 specification schedule will be completed by the procurement agency. The Annex 2 QA assessment will be completed by the installation technician. The Annex 3 checklist will be completed by the user.

5. Specification checklist:

5.1 *Specification requirements:*

Annex 1 lists the required installation(s) and their location(s). Each complete installation (including solar power system and compatible refrigeration equipment) is to be designed and supplied by the qualified supplier using component elements already pre-qualified by WHO in accordance with PQS specifications **E003/PV01.2** and **E003/RF04**, **E003/RF05** or **E003/RF06** and PQS verification protocols **E003/PV01-VP1.1** and **E003/RF04-VP**, **E003/RF05-VP** or **E003/RF06-VP.** Qualified suppliers should consider environmental conditions at the installation site(s) when selecting a suitable refrigerator – for example, in dusty conditions, avoid using models with condenser fins requiring electric blower/fan to clean the fins.

Equipment for known locations is to be designed for climatic conditions at, or as close as possible to, the named site. Equipment for unknown locations is to be designed on the basis of the best available climatic information for the country, region, province or district specified in Annex 1.

5.2 *Criteria for qualification:*

An individual installation will be accepted by the procurement agency when:

- The completed Annex 2 handover checklist shows that all components are correctly installed and are operating satisfactorily.
- A completed Annex 3 user checklist has been received, showing no faults and correct temperature control throughout the first 30 days of operation.

6. Quality control checklist:

6.1 *Quality control standards:*

All installation work must be carried out in accordance with the qualified supplier's installation instructions. All on-site electrical installation work must comply with IEC 60364-1.

6.2 *Manufacturing quality control checklist:*

On-site inspection of the production facility is not required.

6.3 *Site work quality control checklist:*

The installation technician will carry out an inspection of each completed installation and complete a copy of the Annex 2 checklist. If the installation is satisfactory it will be handed over to the user who will complete a copy of the Annex 3 checklist after the first 30 days of operation. The procurement agency will only accept the installation when both checklists are satisfactory.

6.3.1 Training:

User training is optional. If offered, the syllabus should cover the following topics:

- Daily, weekly and monthly maintenance tasks.
- Checking and topping up electrolyte (flooded battery systems only).
- Battery replacement.
- Health and safety guidance.

6.4 *Handover dossier:*

The handover dossier must be issued to the procurement agency after the installation has been completed. The dossier must be presented in a lever arch folder with clearly marked subject dividers and must contain the following:

- Completed, signed, installation checklist.
- User manual, technician's manual and installation manual for the solar power system containing the material listed in specification **E003/PV01.2** clause 4.11.
- User manual for the connected refrigerator complying with clause 4.11 of specification **E003/RF04**, **E003/RF05** or **E003/RF06** (as appropriate).
- Completed, signed, 30-day test checklist.

One copy of the user manual is also to be handed to the responsible person at the installation site.

7. Customer reference checklist:

Not applicable.

8. Pre-qualification evaluation:

Not applicable. Refer to **E003/PV01-VP1.2**

9. Modified products:

Not applicable.

Annex 1 – Specification checklist for known sites

Note: Use this form when the final location of the equipment is known. Complete one copy for each system type.

Solar refrigerator specification checklist for known sites			**Date:**
Country:			
Procurement agency:			
Contact name:			
Address 1:			
Address 2:			
Address 3:			
Address 4:			
Tel:			
Fax:			
Email:			
All system components must be PQS pre-qualified. Refrigerators must comply with specification **E003/RF04** (battery powered), **E003/RF05** (battery-free direct drive) or **E003/RF06** (direct drive, with ancillary battery). Solar power systems must comply with **E003/PV01.**			
SECTION 1: Site			
1.1	*Fields marked * are mandatory. The more precise the other data, the easier it will be for the qualified supplier to design the solar power system to suit the specific site.*	* Country:	
		* Longitude:	
		* Latitude:	
		Nearest city/town:	
		Village or suburb:	
		Site name:	
		Altitude in metres above sea level:	
SECTION 2: Refrigerator and power system			
2.1	**Refrigerator quantity**	Number of units required:	
2.2	**Temperature zone** *Choose the appropriate temperature zone. If winter temperatures are low and site heating is unreliable, specify a freeze prevention circuit.*	Hot zone (+43°C):	☐
		Temperate zone (+32°C):	☐
		Moderate zone (+27°C):	☐
		Cold climate freeze prevention circuit:	Yes ☐ No ☐
		If YES, specify the lowest winter temperature to which the refrigerator will be exposed [1]:	°C
2.3	**Refrigerator model** *Check PQS data sheets for available capacities but do not specify a named model* [2].	Refrigerator only:	☐
		Combined refrigerator & water-pack freezer:	☐
		Minimum vaccine storage capacity:	litres
		Minimum water-pack freezing capacity:	kg/24 hrs
SECTION 3: Power system			
3.1	**Solar power system quantity**	Solar power units required:	
3.2	**Solar power system type**	Either: **Type 1**: with battery set:	☐
		Or: **Type 2**: battery-free direct drive	☐
		Or: **Type 2**: direct drive with ancillary battery	☐
3.3	**Array support details** *The chosen array position must*	**Pitched roof mounting?**	Yes ☐ No ☐
		If YES, give roof pitch in degrees:	

[1] This is the lowest temperature in the room housing the refrigerator, NOT the lowest outside air temperature. In cold climates, temperatures down to -10°C may occur in health facilities that are left unattended and unheated for long periods.

[2] *Note:* Some models are refrigerator only with no ice-making capability.

Solar refrigerator specification checklist for known sites			Date:
Country:			
	face as close as possible to South (northern hemisphere) or North (southern hemisphere) and must be completely shade free (including overhead cables) from at least 9:00am to 3:00pm throughout the year. Give orientation in Northern hemisphere as: SE, SSE, S, SSW, SW or in Southern hemisphere as: NE, NNE, N, NNW or NW.	If YES give roof slope orientation:	
		If YES, state roof finish material:	
		If YES, height of building to eaves:	m
		Flat roof mounting?	Yes ☐ No ☐
		If YES, height of building to roof:	m
		If YES, state roof finish material:	
		Wall mounting?	Yes ☐ No ☐
		If YES, give wall orientation:	
		If YES, give mounting height:	m
		Ground mounting?	Yes ☐ No ☐
		Pole mounting:	Yes ☐ No ☐
		If YES, give height of pole:	m
		If YES, choose top or side mount:	Top ☐ Side ☐
3.4	**Array cable** *Measure the true distance[3] from the array to the battery set position as accurately as possible.*	Length of array cable required:	m
		Measured cable length including all bends, and vertical and horizontal lengths and add 10%.	m
3.5	**Ground conductors** *Agree realistic lengths of ground conductor with the qualified supplier.*	No. of lengths of ground conductor:	
		No. of earth connection fitting kits	

[3] True distance is measured along the actual route the cable will follow. Measure vertically, horizontally and with all changes in direction at 90 degrees.

Annex 2 – Specification checklist for unknown sites

Note: Use this form when the final location of the equipment is unknown. Complete one copy for each system type.

Solar refrigerator specification checklist for unknown sites			**Date:**
Country:			
Procurement agency: Contact name: Address 1: Address 2: Address 3: Tel: Fax: Email:			
All system components must be PQS pre-qualified. Refrigerators must comply with PQS specification **E003/RF04** (battery powered), **E003/RF05** (battery-free direct drive) or **E003/RF06** (direct drive, with ancillary battery). Solar power systems must comply with **E003/PV01.**			
SECTION 1: Location			
1.1	*Field marked * is mandatory. Give as much additional detail as possible.*	* Country:	
		Region(s) or Province(s) (if known):	
		District(s) (if known):	
SECTION 2: Refrigerator			
2.1	**Refrigerator quantity**	Number of units required:	
2.2	**Temperature zone** *Choose the appropriate temperature zone. If winter temperatures are low and site heating is unreliable, specify a freeze prevention circuit.*	Hot zone (+43°C):	☐
		Temperate zone (+32°C):	☐
		Moderate zone (+27°C):	☐
		Cold climate freeze prevention circuit:	Yes ☐ No ☐
		If YES, specify the lowest winter temperature to which the refrigerator will be exposed [4]:	°C
2.3	**Refrigerator model** *Check PQS data sheets for available capacities but do not specify a named model* [5].	Refrigerator only:	☐
		Combined refrigerator & water-pack freezer:	☐
		Minimum vaccine storage capacity:	litres
		Minimum water-pack freezing capacity:	kg/24 hrs
SECTION 3: Power system			
3.1	**Solar power system quantity**	Solar power units required:	
3.2	**Solar power system type**	Either: **Type 1**: with battery set:	☐
		Or: **Type 2**: battery-free direct drive	☐
		Or: **Type 2**: direct drive with ancillary battery	☐
3.3	**PV array support details** *Total of all mounting kits should equal quantity of units specified in 2.1 and 4.1.*	No. of roof/ground mounting kits:	
		No. of pitched roof mounting kits:	
		No. of flat roof mounting kits:	
		No. of wall mounting kits:	
		No. of ground mounting kits:	
3.4	**Array cables**	Typical length of array cable:	m

[4] This is the lowest temperature in the room housing the refrigerator, NOT the lowest outside air temperature. In cold climates, temperatures down to -10°C may occur in health facilities that are left unattended and unheated for long periods.

[5] *Note:* Some models are refrigerator only with no ice-making capability.

	Agree realistic lengths with the qualified supplier. If supplied in large rolls, cables can be cut to suit on each site.		

3.5	**Ground conductors** *Agree realistic lengths of ground conductor with the qualified supplier.*	No. of lengths of ground conductor:	
		No. of earth connection fitting kits	

Annex 3 – Installation checklist

Note: The installation technician must fill in a copy of this checklist for each completed installation.

Solar refrigerator installation checklist			**Date:**
Country:	**City/town:**	**Site name:**	
Installation technician: Installation company: Address 1: Address 2: Address 3: Address 4: Tel: Fax: Email:			
Note: All checks must be satisfactory before the installation is handed over to the user.			
CHECK 1 – System description			
1.1	Qualified supplier:	Name:	
1.2	Photovoltaic panel:	Make:	Model ref:
1.3	Panel mounting frame:	Type of support structure (describe)	
1.4	Refrigerator:	Make:	Model ref:
1.5	Power system:	Direct drive (**RF05/RF06**) ☐ Battery-powered (**RF04**) ☐	
	If 'battery-powered' complete 1.6, otherwise go to **CHECK 2:**		
1.6	Battery powered systems:	Battery set make:	Model ref:
		Battery type:	Sealed ☐ Flooded ☐
		Charge regulator make:	Model ref:
CHECK 2 – Shipment details			
2.1	Was the shipment damaged?		Yes ☐ No ☐
	If YES, describe damage:		
2.2	Were any components missing?		Yes ☐ No ☐
	If YES, list missing parts:		
2.3	Were any components under-supplied?		Yes ☐ No ☐
	If YES, list under-supplied parts:		
2.4	Were any spare parts missing?		Yes ☐ No ☐
	If YES, list missing parts:		
2.5	Were any spare parts under-supplied?		Yes ☐ No ☐
	If YES, list under-supplied parts:		
2.6	Have damaged/missing/under-supplied parts been replaced?		Not applicable ☐ Yes ☐ No ☐
	If NO, describe action taken to complete the installation:		
	Comments:		
CHECK 3 – Photovoltaic panel installation			
3.1	Panel orientation:		
3.2	Panel slope (measure angle relative to the horizontal):		degrees
3.3	Do shadows fall on the panel between 9:00am and 3:00pm?		Yes ☐ No ☐
	If YES, the system FAILS and the panel must be moved.		
3.4	Panel support structure:	Anodized aluminium:	Yes ☐ No ☐
		Stainless steel:	Yes ☐ No ☐
		Galvanized steel (painted or unpainted):	Yes ☐ No ☐
		Other (material (describe):	
	If 'other material', the structure does not comply and must be replaced.		
	Are foundation pads or roof fixings in place and are they adequate?		Yes ☐ No ☐
	Have theft-deterrent fasteners been used?		Yes ☐ No ☐
3.5	Lightning protection:		

Solar refrigerator installation checklist			Date:
Country:	**City/town:**	**Site name:**	
	Has the lightning protection circuit been correctly fitted?		Yes ☐ No ☐
	Has the earth electrode been correctly fitted?		Yes ☐ No ☐
	Has lightning protection system been tested for electrical continuity?		Yes ☐ No ☐
3.6	Array cable:		
	Is the solar array cable type correct for the specified application?		Yes ☐ No ☐
	Is the solar array cable protected against mechanical damage?		Yes ☐ No ☐
	Is the solar array cable protected against rodent attack?		Yes ☐ No ☐
	Comments:		
CHECK 4 – Battery installation (where applicable)			
4.1	Battery set and battery set housing:	Applicable ☐ Not applicable (go to 5)	☐
	Accessible for maintenance?		Yes ☐ No ☐
	Protected against the weather?		Yes ☐ No ☐
	Safely located to prevent accidental damage?		Yes ☐ No ☐
	Secured against theft?		Yes ☐ No ☐
	Have battery safety instructions been provided?		Yes ☐ No ☐
	Have battery maintenance instructions been provided?		Yes ☐ No ☐
4.2	Flooded batteries (where fitted):	Applicable ☐ Not applicable (go to 4.3)	☐
	Are battery casings transparent?		Yes ☐ No ☐
	Was the electrolyte (acid) supplied in a separate sealed container?		Yes ☐ No ☐
	Has the battery safety equipment kit been supplied?		Yes ☐ No ☐
4.3	Battery charge regulator:		
	Was the regulator preset in the factory?		Yes ☐ No ☐
	Does the unit have a correctly labelled 'array charging' indicator?		Yes ☐ No ☐
	Does the unit have a correctly labelled 'low battery' indicator?		Yes ☐ No ☐
	Does the unit have a correctly labelled 'load disconnect' indicator?		Yes ☐ No ☐
	Does the unit have an optional acoustic alarm?		Yes ☐ No ☐
4.4	Fuses: 10 no. spare fuses in polythene bag fixed next to fuse box?		Yes ☐ No ☐
	Comments:		
CHECK 5 – Refrigerator			
5.1	Refrigerator or combined refrigerator & water-pack freezer:		
	Casing marked with the correct temperature zone symbol?		Yes ☐ No ☐
	Casing/compressor marked with refrigerant identification?		Yes ☐ No ☐
	Is the thermostat non-adjustable by the user as required?		Yes ☐ No ☐
	Is there an external reading thermometer as required?		Yes ☐ No ☐
	Comments:		
CHECK 6 – Wiring installation			
6.1	Wiring:		
	Has the system been wired in accordance with the qualified supplier's wiring diagram?		Yes ☐ No ☐
	Are all electrical connections concealed and properly protected?		Yes ☐ No ☐
	Has the site installed electrical wiring been tested?		Yes ☐ No ☐
	Comments:		
CHECK 7 – Commissioning tests			
7.1	Commissioning: have all tests been carried out in accordance with the qualified supplier's instructions?		Yes ☐ No ☐
	If YES, describe tests:		
	If NO, explain why tests have not been carried out:		
7.2	Are all system components functioning properly?		Yes ☐ No ☐
	Comments:		
CHECK 8 – Documentation			
8.1	Documentation check:		

Solar refrigerator installation checklist		Date:
Country:	**City/town:**	**Site name:**

	Has a *user manual* been supplied for all system components?	Yes ☐ No ☐
	Are *user manuals* in the correct language?	Yes ☐ No ☐
	Has a *technician's manual* been supplied for all system components?	Yes ☐ No ☐
	Are *technician's manuals* in the correct language?	Yes ☐ No ☐
	Has an *installation manual* been supplied?	Yes ☐ No ☐
	Is the *installation manual* in the correct language?	Yes ☐ No ☐
	Has one complete set of documentation been filed in a lever arch file and given to the procurement agency?	Yes ☐ No ☐
CHECK 9 – Overall conclusions and recommendations		
9.1	Recommendation:	Pass ☐ Fail ☐
	If FAIL, list outstanding work still required:	
	If PASS, the installation can be handed over to the user.	

Installation technician's signature: ……..

Date: ……

Annex 4 – 30-day test checklist

Note: The user must complete this checklist for each installation after the first 30 days of operation.

Solar refrigerator 30-day test checklist		**Date:**
Country:	**City/town:**	**Site name:**
Instructions for completing this form: Complete the form 30 days after the refrigerator was handed over to you. Send a copy of the form back to Attach a copy of the temperature record for the whole 30 day test period.		
Name: Position: Tel:		

Have you received training in the use of the system?	Yes ☐ No ☐
Do you have a copy of the *user manual* for the solar panels, battery set and refrigerator?	Yes ☐ No ☐
Is the system working correctly?	Yes ☐ No ☐
Has the refrigerator temperature stayed between +2°C and + 8°C throughout the last 30 days?	Yes ☐ No ☐
Have you attached a copy of the temperature record for the last 30 days?	Yes ☐ No ☐
Have you checked that all the indicator lights work correctly?	Yes ☐ No ☐
If NO, which of the lights did you see in operation?	

Comments and questions:
If you have any comments or questions about the equipment or the installer, please write them here:

User's signature: …….

Date: ……

Revision history:			
Date	Change summary	Reason for change	Approved
03.04.2007	Amended to final PQS format.		
09.05.2007	Revised to SMc comments & teleconference UK, SMc, AG 26.04.07		
16.05.2007	Final review version		
06.07.2010	'Icepack' changed to 'water pack'. Generally: Cross references added to E003/RF06 equipment. 1: Scope description changed. 2: Normative references updated. Annex 1: Revised and split into Annex 1 and Annex 2. Annex 2: 3.5 added. Annex 3: 3.5 added. Annex 3: Amended Annex 4: Amended.	Compatibility with new E003/RF06 documents.	