



**TITLE: Power systems for ultra-low temperature freezing systems**

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**1. Scope**

Ultra-low temperature (ULT) freezing systems including at least one ultra-low temperature (ULT) freezer operating to -86°C plus at least one ULT coolant freezer are required for specific vaccines including Ebola vaccine and possible future vaccines. WHO PQS has identified the requirements for ULT freezers and ULT freezing systems per the equipment performance specification **WHO PQS E003/ULT01.0 Vaccine ultra-low temperature freezer: compression-cycle.**

In addition, WHO PQS has identified the need for robust and reliable power systems to support [ULT freezers](#) and [ULT freezing systems](#). **WHO PQS E003/POW01.0** is a power system specification and is intended to provide requirements for [continuous electricity](#) systems to sustain operations of at least one [ultra-low temperature \(ULT\) freezer](#) or an integrated [ULT freezing system](#) that may include any or all of the following electricity consuming [load](#) devices including [ULT freezers](#) for vaccines, [ULT freezers](#) for [ULT coolants](#), standard [water-pack freezers](#), vaccine refrigerators, voltage stabilizers, [equipment monitoring systems \(EMS\)](#), lighting, communications, office devices, ventilation and space cooling.

The **WHO PQS E003/POW01.0** equipment specification describes the requirements for a generic [prime power generator](#) system (single or three-phase [alternating current \(AC\)](#) electricity) and an [uninterruptible power supply \(UPS\)](#). It also describes the [installation](#) and maintenance advisory services that all [legal manufacturers](#) must offer in order to become a prequalified supplier of electric power systems for [ULT freezers](#) or an integrated [ULT freezing system](#).

Historically, [ULT freezers](#) and [ULT freezing systems](#) operate with electric vapor compression refrigeration which is powered with single or three-phase [alternating current \(AC\)](#) electricity supplied by a [reliable electricity](#) supply and distribution system (e.g. “grid”, “[mains](#)”). This specification will include requirements for sites with [reliable electricity](#), [unreliable electricity](#), [limited electricity](#) or [no electricity](#).

Given the critical nature of Ebola vaccine and possible future vaccines requiring [ULT freezers](#) an electric power supply system must be [continuous](#) and therefore all power systems will be required to be backed-up by a second power supply capable of providing 100% of the [ULT freezing system](#) electrical requirements continuously. In addition, both [ULT vaccine freezers](#) will require a battery based [uninterruptible power supply \(UPS\)](#).

**WHO PQS E003/POW01.0** provides the specifications for [continuous electricity](#) systems capable of sustaining [ULT freezers](#) and [ULT freezing systems](#). This specification includes [generators](#) and [UPS systems](#).

Suppliers of electric systems per **WHO PQS E003/POW01.0** can prequalify through the requirements of **WHO PQS E003/POW-VP1** type examination protocol.

**WHO PQS E003/POW01.0** and a completed **WHO PQS E003/POW-VP2** quality assurance protocol, together with an [employer](#)'s other documents, are intended to form the basis for a contractual agreement between the [employer](#) and the [legal manufacturer](#) or [reseller](#) for the supply and [installation](#) of the components required for a specific power system for [ULT freezers](#) and/or [ULT freezing systems](#). This also forms the basis for a contractual agreement between the [employer](#) and the approved [installer](#).

The following documents are associated with this equipment specification:

For [continuous electricity](#) systems see also:

- **WHO PQS E003/POW01.0-VP 0.1 Power systems for ultra-low temperature freezing systems** – type examination for prequalifying suppliers of power systems.
- **WHO PQS E003/POW01.0-VP 0.1 Power systems for ultra-low temperature freezing systems- type examination.**

For [ultra-low temperature \(ULT\) freezer](#) appliances see:

- **WHO PQS E003/ULT01.0 Vaccine ultra-low temperature freezer: compression-cycle** - an equipment performance specification.
- **WHO PQS E003/ULT01.0 VP.1 Vaccine ultra-low temperature freezer: compression-cycle** - verification protocol for prequalification evaluations.

For [water-pack freezer](#) appliances see:

- **WHO PQS E003/FZ01 Vaccine freezer of combined vaccine and water-pack freezers** - an equipment performance specification.

For [hybrid solar power systems](#) see:

- **WHO PQS E001/PVAC01.0 Solar power system for cold and freezer rooms** - an equipment performance specification.
- **WHO PQS E001/PVAC-VP1** - a type-examination protocol.
- **WHO PQS E001/PVAC-VP2** – a quality assurance protocol.

## 2. Terms and definitions

[Alternating current \(AC\)](#): an electric current that reverses its direction at regularly recurring intervals whose value varies as a sine wave.

[Automatic transfer switch \(ATS\)](#): self-acting equipment for transferring one or more load conductor connections from one electric power source to another.

[Back-up generator](#): a secondary prime power generator capable of independently powering 100% of all ULT freezer system electrical needs and battery recharging (if applicable).

[Back-up power](#): a secondary, auxiliary power source (e.g. generator, UPS) capable of independently powering 100% of all ULT freezer system electrical needs.

[Battery charger](#): equipment that converts ac power to dc power and is used to recharge and maintain a station battery in a fully charged condition and to supply power to dc loads during normal operation and design basis events.

[Continuous electricity](#): the sustained supply of electricity adequate for a ULT freezing system.

[Design day](#): the maximum amount of energy expected to be consumed in a day by the ULT freezing system and associated loads like lighting and air conditioning. For purposes of sizing the continuous electricity system, the design day must be calculated using the largest of these three options: 1) the energy required by the entire system based on the peak ambient temperature the ULT freezers are exposed to; 2) the energy required by the entire system based on the highest average daily load requirement for a given month (e.g. months with a high air conditioning load); or 3) both simultaneously (e.g.

months with a high air conditioning load and the peak ambient temperature around the ULT freezers).

**Direct current (DC):** an electric current flowing in one direction.

**Employer:** the organization that contracts with the legal manufacturer or reseller who will supply the system components and the installation and maintenance advisory services described in this specification. The employer will typically contract with an installer who will install and commission the installation under the supervision of a QA assessor and also with a maintenance contractor who will maintain the installation.

**Equipment monitoring systems (EMS):** remote temperature and event monitoring system.

**Generator:** an independent source of electrical power that consists of a fueled internal combustion engine (or engines) coupled directly to an electrical generator (or generators); the associated mechanical and electrical auxiliary systems; and the control, protection, and surveillance systems.

**Hybrid solar power system:** solar power system with one or more auxiliary sources of power (e.g. generator).

**Independent evaluator:** person or organizations who has been appointed by WHO to conduct a type examination per this verification protocol.

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

**Installation:** the complete electrical generator power system installation described in this specification together with any other employer's requirements documentation issued for a specific installation or installations including equipment monitoring systems (EMS), uninterruptible power supply (UPS) systems, hybrid solar power systems, and voltage stabilizers where these are listed in the employer's requirements.

**Installer:** a person or organization who has been appointed by the employer to carry out the installation of the generator system. A qualified installer may be either a legal manufacturer or a reseller or an approved representative and must:

- supply a coherent, correctly sized installation where the settings of all the components have been adjusted for optimum performance at the installation site,
- have installed and supported (e.g. by providing on-going technical assistance, spare parts and system documents) at least five prime generator systems in a developing country or countries for at least two years (detailed references, including donors, locations and contacts, must be provided for independent verification),
- have the capacity and financial resources to provide long-term support to the systems in the country of destination.

**Inverter/charger:** is a combination of an inverter, battery charger and automatic transfer switch into one complete system. When AC power is available, the inverter/charger recharges the batteries. It also allows any surplus AC power to pass through and power downstream AC loads. When AC power is disconnected, the unit inverts DC battery power into AC electricity.

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

**Limited electricity:** an existing electric power system with inadequate capacity to sustain the continuous supply of alternating current electricity adequate for a ULT freezing system.

**Load:** any end-use device in an electrical circuit that can consume power when the electrical circuit is energized.

**Mains electricity:** power delivered by the utility, grid, or other domestic source.

**Maintenance contractor:** a person or organization contracted by the employer to maintain the installation.

**Manual transfer switch (MTS):** an electrical device that allows a user to switch a load between two different electric power sources.

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

**No electricity:** the existing site condition when there is no alternating current electric supply system.

**Prime power generator:** a generator that is able to run for an unlimited amount of time at variable loads up to the maximum rated power.

**QA assessor:** the person or organization appointed by the employer to assess the suitability of candidate installers, to evaluate their proposals and to monitor the assembly and commissioning of the installation on site.

**QA:** quality assurance.

**Region:** a contiguous geographical area within which the legal manufacturer or reseller is able to provide the full range of services described in this specification.

**Reliable electricity:** the existing site condition where a sustained supply of alternating current electricity adequate for a ULT freezing system is continuous where power outages are rare with a maximum of one outage per month of less than 1-hour duration.

**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.

**Reserve time:** the time that a fully charged battery can satisfy the load with no contribution from the charging source.

**Site assessor:** a professional engineer with experience in the design of electrical generators and uninterruptible power systems.

**Site assessment:** process of establishing the electrical power system needs of a specific health facility where an ULT freezing system is proposed.

**User:** the person responsible for the day to day operation and temperature monitoring of the ULT freezer and/or continuous power system.

**Ultra-low temperature (ULT) freezer:** a vaccine freezer that complies with equipment performance specification PQS E003/ULT01.1.

**Ultra-low temperature (ULT) freezing system:** a system of required electrical devices supporting a ULT freezing facility. The devices may vary from site to site and could include ULT vaccine freezers, standard water-pack freezers, vaccine refrigerators, equipment monitoring systems (EMS), lighting, communications, office devices, ventilation and space cooling.

**Uninterruptible power supply (UPS):** a backup stored energy system that protects a load from power outages using a stored energy system.

**Unreliable power:** the existing site condition where a sustained supply of alternating current electricity adequate for a ULT freezing system is less than 23 hours/day and may also experience power outages of more than once per month with one-hour duration or longer.

### 3. Normative references

Use most recent version.

BS EN 60529:1992+A2:2013: Degrees of Protection by Enclosures (IP Code)

EMAS: European Union Eco-Management and Audit Scheme.

EPA emissions, stationary emergency, Part 60 Subpart IIII: New Source Performance Standards (NSPS) for Stationary Compression Ignition Internal Combustion Engines.

Directive 2006/42/EC: Machinery.

Directive 2014/35/EU Harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

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

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

IEC 60335-2-24: Household and similar electrical appliances – Safety

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

IEC 60529:1989+AMD1:1999+AMD2:2013 CSV Consolidated version Degrees of protection provided by enclosures (IP Code)

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 62040-1:2017/COR1:2019 Corrigendum 1 - Uninterruptible power systems (UPS) - Part 1: Safety requirements

IEC 62257-7-3: Recommendations for renewable energy and hybrid systems for rural electrification – Part 7-3: Generator set – Selection of generator sets for rural electrification systems.

IEC 62477-1: Safety requirements for power electronic converter systems and equipment - Part 1: General.

IEC 62909-1: Bi-directional grid connected power converters - Part 1: General requirements.

IEEE Standard 446: Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

IEEE Standard 485: Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.

IEEE Standard 1184: Guide for Batteries for Uninterruptible Power Supply Systems.

INCO terms 2020.

ISO 3026-1: Reciprocating internal combustion engines — Performance.

ISO 8528: Reciprocating internal combustion engine driven alternating current generating sets.

ISO 9001: Quality Management Systems – Requirements.

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

WHO PQS E001/PVAC 01: Solar power system for cold and freezer rooms.

WHO PQS E001/PVAC 01-VP.1: PQS Independent type examination (TBD).

WHO PQS E001/PVAC 01-VP.2: PQS Quality Assurance Protocol (TBD).

WHO PQS E003/FZ01: Vaccine freezer or combined vaccine and water-pack freezers.

WHO PQS E003/ULT01.0: Vaccine ultra-low temperature freezer: compression-cycle.

WHO PQS E003/ULT01 VP.1: Vaccine ultra-low temperature freezer: compression-cycle.

#### 4. Applicability

[ULT freezers](#) will be supplied according to **WHO PQS E003/ULT01.0** and [continuous electricity](#) systems will be supplied according to **WHO PQS E003/POW01.0**. The **Annex 1 site assessment** checklist will be completed by the [employer](#). The **Annex 2**



specification checklist will be completed by the [employer](#). The **Annex 3 QA** assessment will be completed by the [installer](#). The **Annex 4** checklist will be completed by the [user](#).

## 5. Specification checklist

### 5.1 Specification requirements

**Annex 2** lists the required [installation\(s\)](#) and their location(s). Each complete [installation](#) (including [UPS](#) and a [continuous electricity](#) system and PQS complying [ULT freezers](#)) must be designed and supplied using freezers and refrigerators prequalified by WHO in accordance with PQS specifications (per applicable, active WHO PQS E003 documents) and a [continuous electricity](#) supply system per the requirements of **E003/POW01.0**. [Legal manufacturers](#) and [resellers](#) are required to consider environmental conditions at the [installation](#) site(s) when selecting suitable components – for example, in dusty conditions, avoid using components requiring frequent cleaning maintenance. Equipment for known locations must be designed for climatic conditions at, or as close as possible to, the named site. Equipment for unknown locations must be designed on the basis of the best available climatic information for the country, [region](#), province or district specified in **Annex 1**, Part 1, line 1.1.

### 5.2 Criteria for qualification

An individual [installation](#) will be accepted by the [employer](#) when the completed **Annex 3** handover checklist shows that all components are correctly installed and are operating satisfactorily and a completed **Annex 4 user** checklist has been received, showing no faults and correct operation 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 [legal manufacturer's installation](#) instructions. All on-site electrical [installation](#) work must comply with **IEC 60364-1** and applicable national/local codes.

### 6.2 Manufacturing quality control checklist

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

### 6.3 Site work quality control checklist

The [installer](#) will carry out an inspection of each completed [installation](#) and complete a copy of the **Annex 3** checklist. If the [installation](#) is satisfactory it will be handed over to the [user](#) who will complete a copy of the **Annex 4** checklist after the first 30 days of operation. The [employer](#) 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:

- operations
- daily, weekly and monthly maintenance tasks
- health and safety guidance
- basic troubleshooting
- decommissioning.

### 6.4 Handover dossier

The handover dossier must be issued to the **employer** 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, installer (technician) manual and installation instructions for the continuous electricity system containing the material listed in specification E003/POW01.0
- 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. Prequalification evaluation**

Not applicable.

### **9. Modified products**

Not applicable.



## Annex 1 – Site assessment checklist

<b>PART 1: Site assessment details</b>		
1.1	<b>Assessment date</b>	
1.2	<b>Site assessor(s)</b>	
1.2.1	Contact information	
1.3	<b>Site details</b>	
1.3.1	Name	
1.3.2	Address	
1.3.3	Latitude	
1.3.4	Longitude	
1.3.5	Elevation (metres)	
1.4	<b>Site contact details</b>	
1.4.1	Name	
1.4.2	Email	
1.4.3	Landline	
1.4.4	Mobile phone	
1.5	<b>Meeting details</b>	
1.5.1	Time	
1.5.2	Location	
1.6	<b>Nearest food and lodging</b>	
1.6.1	Name	
1.6.2	Address	
1.6.3	Latitude	
1.6.4	Longitude	
<b>PART 2: Transportation details</b>		
2.1	<b>Starting Point</b>	
2.2	<b>Distance to site</b>	
2.3	<b>Estimated time to site</b>	
2.4	<b>Phone reception/provider</b>	
2.5	<b>Road conditions</b>	
2.6	<b>Security considerations</b>	
2.7	<b>Waterway crossings</b>	
2.8	<b>Bridges</b>	
2.9	<b>Other hazards</b>	
2.10	<b>Detailed directions</b>	

<b>PART 3: Site survey and assessment tool list</b>		
3.1	<b>Tools to bring to site assessment</b>	
	<input type="checkbox"/> First-aid kit <input type="checkbox"/> Overnight kit <input type="checkbox"/> Water / water purification filter or tablets <input type="checkbox"/> Food <input type="checkbox"/> Sunscreen / hat <input type="checkbox"/> Notebook, pencils, pens <input type="checkbox"/> Knife <input type="checkbox"/> Camera (fully charged) <input type="checkbox"/> Cell phone (fully charged) <input type="checkbox"/> GPS (fully charged) <input type="checkbox"/> Tool belt / box (hammer, screwdrivers, adjustable wrench, pliers, tape measure) <input type="checkbox"/> Multimeter <input type="checkbox"/> Thermometer <input type="checkbox"/> Other (specify below)	
<b>PART 4: Facility details</b>		
4.1	<b>Interviewee (expand as needed)</b>	
4.1.1	Name	
4.1.2	Position	
4.1.3	Contact details	
4.2	<b>Facility</b>	
4.2.1	Owned by	
4.2.2	Operated by	
4.2.3	Age	
4.2.4	General condition	
4.2.5	Time(s) open	
4.2.6	Number of staff	
4.2.7	On site electrical technicians	Yes No
4.2.8	Guards	Yes No
4.2.9	Security history	
4.3	<b>Electricity</b>	
4.3.1	Voltage and frequency	
4.3.2	Service entrance capacity	
4.3.3	Type of electricity (refer to definitions)	Reliable electricity Unreliable electricity Limited electricity No electricity
4.4	<b>Availability of electricity:</b> note type – mains, on-site generator(s), or hybrid (e.g. mains plus back-up generator, solar plus back-up generator, other)	
4.4.1	Type of electricity supply	

4.4.2	Hours per day	
4.4.3	Source of information	
4.4.4	Power outage frequency	
4.4.5	Typical outage duration (hours)	
4.4.6	Longest recalled power outage (hours)	
<b>PART 5: ULT freezer placement (if location is known)</b>		
5.1	<b>ULT freezer details (if known)</b>	
5.1.1	Manufacturer	
5.1.2	Model No.	
5.1.3	WHO PQS code	
5.1.4	Width x depth x height (cm)	
5.1.5	Weight (kg)	
5.2	<b>No. of ULT freezers (if known)</b>	
5.3	<b>Clearance for ventilation (cm)</b>	
5.4	<b>ULT freezer location(s)</b>	
5.5	<b>Are all ULT freezers in the same room?</b>	
5.6	<b>Room name</b>	
5.7	<b>Room dimensions</b>	
5.7.1	Width x depth x height (cm)	
5.8	<b>Door width x height (cm)</b>	
5.9	<b>Is room vented or air conditioned?</b>	
5.10	<b>If no, how will heat escape?</b>	
5.11	<b>Is roof watertight?</b>	
5.12	<b>Is floor strong and level?</b>	
5.13	<b>Is there any heat gain on the ULT freezer?</b>	
5.14	<b>Building materials (note wall, floor and roof construction including insulation)</b>	
<b>PART 6: Load details</b>		
6.1	<b>ULT freezer</b>	Manufacturer/model:
6.2	<b>Design day load(s)</b> <i>manufacturer, model and electrical data (e.g. voltage, frequency, single or three phase, quantity, watt, hours per average day and design day Watt hours/day).</i> <i>Expand list as necessary.</i>	<b>Load 1: ULT vaccine freezer (design day watt hours/day)</b>
		<b>Load 2: ULT coolant freezer (design day watt hours/day)</b>  <i>Expand list as necessary.</i>
6.3	<b>Temperature zone</b> <i>Choose the appropriate temperature zone for ambient surrounding ULT freezers.</i> <i>Expand list as necessary.</i>	Hot zone (+43°C) <b>note: may require space cooling</b> Temperate (+32°C) <b>note: may require space cooling</b> Moderate (+25°C)
6.4	<b>Air conditioning or ventilation</b> <i>manufacturer, model and electrical data (e.g. voltage,</i>	

	<i>frequency, single or three phase, quantity, watt, hours per average day and design day Watt hours/day).</i> <i>Expand list as necessary.</i>	
6.5	<b>Lighting</b> <i>(Quantity, watt, hours per average day and design day Watt hours/day).</i> <i>Expand list as necessary.</i>	
6.6	<b>Office equipment</b> <i>Computers, phones, etc.</i> <i>(Quantity, watt, hours per average day and design day Watt hours/day).</i> <i>Expand list as necessary.</i>	
6.7	<b>Other</b> <i>Specify</i> <i>(Quantity, watt, hours per average day and design day watt hours/day).</i> <i>Expand list as necessary.</i>	
<b>PART 7: Design Considerations</b>		
7.1	<b>Availability of service technician</b>	On site, nearby, other?
7.1.1	<b>Availability of spare parts on-site</b>	
7.1.2	<b>Availability of spare parts – off site</b>	
7.1.3	<b>Typical time to repair electrical problems (from discovery to completion)</b>	
7.2	<b>Availability of fuel delivery</b>	1 day, 7 day, other?
<b>PART 8: Photographs (as needed)</b>		
8.1	<b>Photographs taken</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Building</li> <li><input type="checkbox"/> ULT freezer room</li> <li><input type="checkbox"/> UPS room (if different from ULT freezer room)</li> <li><input type="checkbox"/> Location of UPS battery (if different from UPS room)</li> <li><input type="checkbox"/> Electric service entrance</li> <li><input type="checkbox"/> Electrical panels</li> <li><input type="checkbox"/> Existing generator (if applicable)</li> <li><input type="checkbox"/> Location for new generator (if applicable)</li> <li><input type="checkbox"/> Wiring distance new generator to ULT freezer room</li> <li><input type="checkbox"/> Location for fuel storage (if applicable)</li> <li><input type="checkbox"/> Air conditioning equipment (if applicable)</li> <li><input type="checkbox"/> Other (specify below)</li> </ul>	

<b>PART 9: Construction detail sketches (as needed)</b>	
9.1	<b>Construction detail sketches made</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> ULT freezer room dimensions / door dimensions / wall and floor material / details</li> <li><input type="checkbox"/> UPS room (if different from ULT freezer room) dimensions / door dimensions / wall and floor material / details</li> <li><input type="checkbox"/> UPS battery (if different from UPS room) dimensions / door dimensions / wall and floor material / details</li> <li><input type="checkbox"/> Generator location dimensions / door dimensions (if applicable) / wall and floor material / details</li> <li><input type="checkbox"/> Fuel storage location (if different than generator location) dimensions / filling location / details</li> <li><input type="checkbox"/> Wiring: entry(s) into building, ground detail, and if needed conduit and fittings</li> <li><input type="checkbox"/> Wiring distances</li> <li><input type="checkbox"/> Other (specify below)</li> </ul>
<b>PART 10: Design conclusion</b>	
10.1	<b>Required UPS time (hours)</b>
10.2	<b>Continuous electricity recommendation (e.g. mains plus back-up generator)</b>
10.3	<b>Required fuel storage (days)</b>
10.4	<b>Additional WHO PQS compliance requirements (list below)</b>

## Annex 2 – Specification checklist

### Notes:

- The **employer** should complete one checklist for each **known** site (Part 3).
- For **unknown** sites, complete one checklist (Part 4) for each type and size of **continuous electricity** systems. Technical assistance may be required to estimate electrical load, design day and **continuous electricity** system requirements.

Continuous electricity system specification checklist		Date:
<b>Country:</b>		
Procurement agency:		
Contact name:		
Address 1:		
Address 2:		
Address 3:		
Address 4:		
Tel:		
Fax:		
Email:		
All system components must comply with applicable PQS specifications. The ULT freezer(s) must be prequalified to most recent version of PQS specification <b>E003/ULT</b> Continuous electricity systems must comply with most recent version of PQS specification <b>E003/POW</b> .		
<b>PART 1: Site information</b>		
1.1	<b>Site location and Quantity</b> <i>The continuous power system for equipment on unknown sites will be a generic design.</i>	<b>Known</b> (complete Part 2 and Part 3 only) Qty =
		<b>Unknown</b> (complete Part 2 and Part 4 only) Qty =
<b>PART 2: Load details</b>		
2.1	<b>ULT freezer</b>	Manufacturer/model:
2.2	<b>Design day load(s)</b> <i>manufacturer, model and electrical data (e.g. voltage, frequency, single or three phase, quantity, watt, hours per average day and design day Watt hours/day). Expand list as necessary.</i>	<b>Load 1: ULT vaccine freezer</b> (design day Watt hours/day)
		<b>Load 2: ULT coolant freezer</b> (design day Watt hours/day)
		<i>Expand list as necessary.</i>
2.3	<b>Temperature</b> <i>Choose the appropriate temperature zone for ambient surrounding ULT freezers or</i>	Hot zone (+43°C) <b>note: site requires space cooling:</b>
		Temperate zone (+32°C):
		Moderate zone (+27°C):
		Estimated ambient temperature



Continuous electricity system specification checklist		Date:	
Country:			
	<i>Enter estimated temperature. Expand list as necessary.</i>	Average high ambient temperatures Record high ambient temperature Source of temperature data	
2.4	<b>Air conditioning or ventilation</b> <i>manufacturer, model and electrical data (e.g. voltage, frequency, single or three phase, quantity, watt, hours per average day and design day Watt hours/day). Expand list as necessary.</i>		
2.5	<b>Lighting</b> <i>(Quantity, watt, hours per average day and design day Watt hours/day). Expand list as necessary.</i>		
2.6	<b>Office equipment</b> <i>Computers, phones, etc. (Quantity, watt, hours per average day and design day Watt hours/day). Expand list as necessary.</i>		
2.7	<b>Other</b> <i>Specify (Quantity, watt, hours per average day and design day Watt hours/day). Expand list as necessary.</i>		
2.8	<b>Design day assumptions</b>		
PART 3: Known sites			
3.1	<b>Known site location details</b> <i>Fields marked * are mandatory. The more precise the other data, the easier it will be to design for the specific site.</i>	* Country:	
		* Longitude:	
		* Latitude:	
		Nearest city/town:	
		Village or suburb:	
		Site name:	
		Altitude in metres above sea level:	
3.2	<b>Type of electricity</b> <i>Refer to definitions</i>	Reliable electricity Unreliable electricity Limited electricity No electricity	
3.3	<b>Uninterruptible power supply (UPS)</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.1	Yes No
3.4	<b>UPS type (note if single or double conversion)</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.1	Yes No Type _____

Continuous electricity system specification checklist			Date:
Country:			
3.5	UPS Sizing	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.1 using assessor's backup time requirement	Yes No Backup time
3.6	Battery type	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.1	Yes No
3.7	Battery set sizing	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.2 using assessor's backup time requirement	Yes No Backup time
3.8	Battery set housing	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.3	Yes No
3.9	Battery safety kit	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.4	Yes No
3.10	Battery location/notes:		
3.11	UPS charger	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.3	Yes No
3.12	Battery recharge time <i>Less than 24 hours</i>	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.3	Time _____
3.13	Battery charger location/notes:		
3.14	UPS inverter	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.4	Yes No
3.15	Inverter location/notes:		
3.16	UPS manual transfer switch	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.5	Yes No
3.17	UPS ATS (if applicable) <i>transfer time</i>	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.5	Yes No Mains to invert ___ Invert to mains
3.18	Disconnects	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.6	Yes No
3.19	Monitoring and alarms	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.7	Yes No
3.20	Generator	Per WHO/PQS/E003/POW01.0 Clause 4.2.2	Yes No
3.21	Generator type	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.2	Type _____
3.22	Generator startup time <i>Less than 5 minutes</i>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.3	Time _____

<b>Continuous electricity system specification checklist</b>		<b>Date:</b>	
<b>Country:</b>			
3.23	<b>Generator manual transfer switch</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.4	Yes No
3.24	<b>Generator ATS</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.4	Yes No
3.25	<b>Generator sizing</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.5	Yes No
3.26	<b>Paralleled generators</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.6	Yes No Not Applicable
3.27	<b>Generator requirements</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.7	Yes No
3.28	<b>Generator earthing</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.8	Yes No
3.29	<b>Generator starting system</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.9	Yes No
3.30	<b>Stored fuel capacity and fuel tank</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.10	Yes No
3.31	<b>Monitoring and alarms</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.11	Yes No
3.32	<b>Generator accessories</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.12	Yes No
3.33	<b>Generator installation</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.13	Yes No
3.34	<b>Generator location/notes:</b>		
3.35	<b>Generator manual</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.14	Yes No
3.36	<b>Generator spare parts</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.15	Yes No
3.37	<b>Electrical safety</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.3	Yes No
3.38	<b>Electrical protection</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.4	Yes No
3.39	<b>Lightning, surge protection, and grounding</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.5	Yes No
3.40	<b>Tool kits</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.6	Yes No
3.41	<b>Electromagnetic compatibility</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.7	Yes No
3.42	<b>Fire safety equipment</b>	Per WHO/PQS/E003/POW01.0 Clause 4.2.8	Yes No

Continuous electricity system specification checklist		Date:	
Country:			
3.43	Warranty	Per WHO/PQS/E003/POW01.0 Clause 4.8	Yes No
3.44	Warranty options/notes:		
3.45	Essential spare parts	Per WHO/PQS/E003/POW01.0 Clause 4.9.2	Yes No
PART 4: Unknown sites			
4.1	Unknown site location details <i>Field marked * is mandatory. Give as much additional detail as possible.</i>	* Country:	
		Region(s) or Province(s) (if known):	
		District(s) (if known):	
4.2	Continuous power system quantity	Units required:	
4.3	Uninterruptible power supply (UPS)	Per WHO/PQS/E003/POW01.0 Clause 4.2.1	Yes No
4.4	UPS type (note if single or double conversion)	Per WHO/PQS/E003/POW01.0 Clause 4.2.1	Yes No Type
4.5	UPS Sizing	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.1 using assessor's backup time requirement	Yes No Backup time
4.6	Battery type	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.1	Yes No
4.7	Battery set sizing	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.2 using assessor's backup time requirement	Yes No Backup time
4.8	Battery set housing	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.3	Yes No
4.9	Battery safety kit	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.2.4	Yes No
4.10	UPS charger	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.3	Yes No
4.11	Battery recharge time <i>Less than 24 hours</i>	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.3	Time _____
4.12	UPS inverter	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.4	Yes No
4.13	UPS manual transfer switch	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.5	Yes No
4.14	UPS ATS (if applicable) <i>transfer time</i>	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.5	Yes No Mains to invert ___ Invert to mains
4.15	Disconnects	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.6	Yes No

Continuous electricity system specification checklist			Date:
Country:			
4.16	Monitoring and alarms	Per WHO/PQS/E003/POW01.0 Clause 4.2.1.7	Yes No
4.17	Generator	Per WHO/PQS/E003/POW01.0 Clause 4.2.2	Yes No
4.18	Generator type	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.2	Type _____
4.19	Generator start-up time <i>Less than 5 minutes</i>	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.3	Time _____
4.20	Generator manual transfer switch	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.4	Yes No
4.21	Generator ATS	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.4	Yes No
4.22	Generator sizing	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.5	Yes No
4.23	Paralleled generators	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.6	Yes No Not Applicable
4.24	Generator requirements	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.7	Yes No
4.25	Generator Earthing	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.8	Yes No
4.26	Generator starting system	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.9	Yes No
4.27	Stored fuel capacity and fuel tank	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.10	Yes No
4.28	Monitoring and alarms	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.11	Yes No
4.29	Generator accessories	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.12	Yes No
4.30	Generator installation	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.13	Yes No
4.31	Generator manual	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.14	Yes No
4.32	Generator spare parts	Per WHO/PQS/E003/POW01.0 Clause 4.2.2.15	Yes No
4.33	Electrical safety	Per WHO/PQS/E003/POW01.0 Clause 4.2.3	Yes No
4.34	Electrical protection	Per WHO/PQS/E003/POW01.0 Clause 4.2.4	Yes No
4.35	Lightning, surge protection, and grounding	Per WHO/PQS/E003/POW01.0 Clause 4.2.5	Yes No
4.36	Tool kits	Per WHO/PQS/E003/POW01.0 Clause 4.2.6	Yes No

Continuous electricity system specification checklist			Date:
Country:			
4.37	Electromagnetic compatibility	Per WHO/PQS/E003/POW01.0 Clause 4.2.7	Yes No
4.38	Fire safety equipment	Per WHO/PQS/E003/POW01.0 Clause 4.2.8	Yes No
4.39	Warranty	Per WHO/PQS/E003/POW01.0 Clause 4.8	Yes No
4.40	Warranty options/notes:		
4.41	Essential spare parts	Per WHO/PQS/E003/POW01.0 Clause 4.9.2	Yes No

### Annex 3 – Installation checklist

Note: The [installer](#) must fill in this checklist for each completed [installation](#).

Continuous electricity installation checklist			Date:
Country:	City/town:	Site name:	
Installation company: Installation technician: Address 1: Address 2: City: Country: Tel: Fax: Email:			
<i>Note: All checks must be satisfactory before the installation is handed over to the user.</i>			
CHECK 1 – Continuous power system			
1.1	Supplier- Legal Manufacturer or Reseller:	Name:	
1.2	UPS: Mfc./Model:  Quantity:  Rating (Volt input/output):  Watt (continuous):		
	UPS components	Complies with WHO PQS POW: 0.1	Yes / No



<b>Continuous electricity installation checklist</b>		<b>Date:</b>	
<b>Country:</b>	<b>City/town:</b>	<b>Site name:</b>	
1.3	<b>Battery:</b> Mfc/Model:  Quantity:  Type:  Wiring: (e.g.4 series x 2 parallel):  Battery rating (Vdc, AH discharge @ C/8 to 1.9 Vpc @+25°C):  Battery location:  Battery enclosure:		
	Battery system:	Complies with WHO PQS POW: 0.1	Yes / No
1.4	<b>Inverter:</b> Mfc/Model:  Quantity:  Type (wave form):  Rating (Volt input/output):  Watt (continuous):		
	Inverter:	Complies with WHO PQS POW: 0.1	Yes / No
1.5	<b>Generator:</b> Mfc/Model:  Quantity:  Fuel:  Rating (Voltage, Hz)  Watt (continuous):  Fuel tank capacity:		
	Generator system:	Complies with WHO PQS POW: 0.1	Yes / No
1.6	<b>Equipment monitoring:</b> Mfc/Model:  Quantity:  Type:		
<b>CHECK 2 - Delivery</b>			
2.1	Was the shipment damaged?		Yes No
	If YES, describe damage:		

<b>Continuous electricity installation checklist</b>		<b>Date:</b>	
<b>Country:</b>	<b>City/town:</b>	<b>Site name:</b>	
2.2	Were any components missing? If YES, list missing parts:	Yes	No
2.3	Were any components under-supplied? If YES, list under-supplied parts:	Yes	No
2.4	Were any spare parts missing? If YES, list missing parts:	Yes	No
2.5	Were any spare parts under-supplied? If YES, list under-supplied parts:	Yes	No
2.6	Have damaged/missing/under-supplied parts been replaced? If NO, describe action taken to complete the installation:  <i>Comments:</i>	Not applicable	Yes No
<b>CHECK 3 – Loads (complete if ULT freezer system loads if an installer responsibility)</b>			
3.1	List load type(s): Do the ULT freezer(s) have a WHO PQS prequalification code number?  Do Equipment Monitoring System(s) have a WHO prequalification code?  List all load(s) installed, expand as needed  <i>Comments:</i>	Yes (list)	No
<b>CHECK 4 – Wiring installation</b>			
4.1	Electrical wiring: Has the system been wired in accordance with the Legal Manufacturer or Reseller’s wiring diagram and instructions? Are all electrical connections concealed and properly protected? Was site installed electrical wiring tested for safety and function? If NO, explain and detail corrective actions planned including safety instructions to users:	Yes	No
<b>CHECK 5 – Commissioning tests</b>			
5.1	Commissioning: have all tests been carried out in accordance with the Legal Manufacturer or Reseller’s commissioning instructions?	Yes	No

<b>Continuous electricity installation checklist</b>		<b>Date:</b>	
<b>Country:</b>	<b>City/town:</b>	<b>Site name:</b>	
	If YES, describe/attach tests for:  ULT freezers (if applicable and installer responsibility):  UPS:  Generator(s):  Equipment Monitoring System(s):  Other:		
	If NO, explain why tests have not been carried out:		
5.2	Are all loads, all UPS and the continuous power system components functioning properly?	Yes	No
	If NO, explain and detail corrective actions planned:		
<b>CHECK 6 – Documentation</b>			
6.1	Documentation check:		
	Have user manuals been supplied for all system components?	Yes	No
	Are user 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 given to the employer and one set of user's documents been given to the responsible on-site user?	Yes	No
<b>CHECK 7 – Overall conclusions and recommendations</b>			
7.1	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.

<b>ULT freezer system continuous electricity system 30-day test checklist</b>		<b>Date:</b>	
<b>Country:</b>		<b>City/town:</b>	<b>Site name:</b>
<p><i>Instructions for completing this form:</i>          Complete the form 30 days after the continuous electricity system was handed over to you.          Send a copy of the form back to &lt;name of recipient&gt;.</p>			
Name:			
Position:			
Tel:			
E-mail:			
Have you received training (Power system? ULT freezers? All other connected ULT freezer system loads)?		Yes	No
Do you have a copy of the <i>user manual</i> for the ULT freezer, equipment monitoring, UPS and the continuous power system?		Yes	No
Were maintenance tools, supplies and consumables provided?		NA	Yes No
Is the UPS working correctly?		Yes	No
List evidence the UPS and continuous electricity system operates correctly:			
Has the ULT freezer(s) operated correctly throughout the last 30 days?		Yes	No
List evidence the ULT freezer(s) operate correctly?			
If you have any comments or questions, please write them here:			
User's signature:			
Date:			

## **Annex 5 - Examples: Assessing electricity requirements for an Ultra-Low Temperature cold chain.**

**Background:** Certain vaccine requires storage in an ultra-low temperature (ULT) freezer with a second ULT freezer dedicated to freezing ULT coolant packs. These vaccines include Ebola and COVID-19 and are considered critical to human health and therefore both the cooling appliances used to store them and electricity needed to power the cooling are considered critical. WHO PQS has established specifications for prequalifying the appliances as well as the specifications for continuous electricity supply systems to sustain ULT freezer systems.

To support storage and distribution of ULT vaccine there may also be the need for a variety of additional cold chain equipment (CCE) including electrical appliances comprised of water-pack freezers and vaccine refrigerators. All WHO prequalified CCE and specific appliances (i.e. vaccine carriers, cold boxes, temperature monitoring, vaccine freezers, vaccine refrigerators and water pack freezers) are found in the WHO PQS online catalog.

The electricity supply for a ULT freezer system must be continuous. This will require at least two sources of electric supply and each ULT vaccine freezer must also be equipped with a dedicated uninterruptible power supply (UPS). The configuration of the two electrical supply systems depends on the availability of electricity at each ULT freezer system site and therefore could be:

1. A reliable mains electricity supply with a back-up generator;
2. An unreliable mains electricity with two generators; or
3. No mains electricity where two generators or a solar hybrid power system coupled to a back-up generator.

In order to ascertain the status of an existing electrical supply system at each candidate site for storing and distributing the ULT vaccines a site assessment is necessary, and this assessment is a requirement of the **WHO PQS E003/POW: 0.1** specification. This annex provides information to assist in completing the required site assessment checklist.

**Role of the electrical system assessor:** It is the responsibility of the employer (buyer) to have a site assessor conduct a facility specific inspection and assessment to document the status of electricity supply at that facility, determine the suitability of continuous electricity solutions and recommend options to meet the PQS compliance requirements for that facility to establish and sustain necessary temperature and electricity supply conditions. These requirements are specified in **WHO PQS E003/POW: 0.1 Power systems for ultra-low temperature freezing systems.**

The quantity, makes and model numbers of the necessary ULT freezers, supporting appliances and other CCE must be pre-selected by the employer or persons other than the site assessor.

Once the quantity, make and model of the ULT freezers are known a site assessor can begin to evaluate a specific location to determine the adequacy of electric supply and options for a continuous electricity system. However, it is not the role of the site assessor to design the details of the continuous electricity solution. This design responsibility involves the buyer (employer) and the supplier (legal manufacturer or reseller).

**The site assessment:** Checklist 1 of the **WHO PQS E003/POW VP0.2** lists the criteria the site assessor will address. A completed Checklist 1 results in a summary of:

1. Existing electric supply (Reliable, Unreliable, Limited or None);
2. Existing back-up electric options (generators, UPS);
3. Placement of the ULT freezer system appliances and necessary supporting loads;
4. Continuous electricity options; and
5. Summary of required actions to comply with the **WHO PQS E003/POW: 0.1** equipment specification for a continuous electric supply.

Larger health facilities located in cities with reliable electricity may also be prepared for electrical outages with back-up generators. This combination of reliable electricity and back-up generator(s) can provide many of the required **WHO PQS E003/POW** specifications. However, all ULT vaccine freezers must be coupled to a UPS with at least eight hours of battery reserve capacity and this UPS is unlikely to be found at most health facilities. A site assessment is still required and may find the need for the UPS to have more than eight hours of battery capacity.

Health facilities with unreliable, limited or no electricity are required to establish a continuous electricity system per the **WHO PQS E003/POW** specifications. This requires a dedicated UPS for each ULT freezer as well as electricity supply that is likely to include dual generators for adequate back-up power. In some cases, a hybrid solar electricity system coupled to a back-up generator may be the solution (see **WHO PQS E001/PVAC Solar power system for cold and freezer rooms** for performance specifications).

**Instructions:** With input from the employer the site assessor must complete the **Annex 1** Site assessment checklist. This will usually require a site visit. At a minimum the following key information should be obtained:

1. Location/contact information
2. Climate factors
3. Cold chain equipment (CCE) inventory and identification of any CCE that will support the ULT freezer system
4. Proposed ULT freezer location(s)
5. Freezer position infrastructure (e.g. lighting, ventilation, cooling, electrical panel and electrical circuit capacity).
6. Electricity supply assessment
7. Back-up power assessment (e.g. generator, make, model, rating, age, condition and fuel capacity)
8. Spare parts program and stock
9. Response time for repairs
10. Compliance recommendations



## 11. New installations logistics

Sites may require additional information. It is recommended the site assessment checklist be used to consider a wide range of considerations. It is possible for highly qualified electricians to complete both the site assessment checklist and establish design detail solutions in the same visit. However, electrical systems may be extremely complicated and therefore the site assessment checklist does not require that suggested solutions be fully detailed.

### **Abbreviated Example 1: Normally reliable electricity**

The example that follows is abbreviated with notes that indicate fictitious findings for key aspects of a site assessment along with notes and suggestions based on the information provided. Multiple solutions for supplying continuous electricity will be possible and this example portrays one possible approach to the conditions noted.

- 1. Location/contact information:** Typical inputs for location and contact persons information must be input by the site assessor.

No difficulty in travel to the site or other complications to installation logistics were observed or were reported in staff interviews. The facility purchasing agent reported long lead times for imported items and believes time delays in shipping and customs were often overlooked during project planning.

- 2. Climate factors:** Ambient temperatures average +25°C and range from an average monthly low of 0°C in January to an average monthly high of +30°C in August. Record temperature was recorded at +40°C. Source of temperature data is documented as [www.weatherbase.com](http://www.weatherbase.com) (other sources of long-term temperature data may be available for given sites).

Note: Location may experience wind storms and/or flooding capable of causing prolonged mains power outages. This results in a power vulnerability as the single back-up generator is shared with the entire facility.

### **3. CCE inventory (abbreviated to only CCE in support of ULT freezer system)**

- a. Vaccine refrigerator(s):**
  - i. Existing: 2 Ice Lined Refrigerators (four-day holdover time) PQS code xxx
  - ii. Existing: 2 Voltage stabilizers PQS code xxx
  - iii. Planned: 1 identical appliance and voltage stabilizer must be added
- b. Water pack freezer(s):**
  - i. Existing: 1 Water pack freezer PQS code xxx
  - ii. Existing: 1 Voltage stabilizer PQS code xxx
  - iii. Planned: 0
- c. ULT vaccine freezer(s):**

- i. Existing: 0
  - ii. Planned: 2 ULT vaccine freezer PQS code xxx
- d. ULT coolant pack freezer(s):**
- i. Existing: 0
  - ii. Planned: 1 ULT coolant pack freezer PQS code xxx

**b. Proposed ULT freezer locations(s):** All ULT freezers and supporting CCE must be located in a dedicated room with mechanically cooled air set at + 25°C (+/- 2°C).

**c. Freezer position infrastructure:** Dedicated room with a level concrete floor, no signs of water intrusion and updated sufficient multiple electrical outlets (each with a 230 Vac, 10-amp rating). The mechanical cooling and room lighting is installed, functioning and is powered by the mains and is connected whenever the back-up generator is energized.

Note: It may not be necessary to electrically isolate the existing lighting, cooling, vaccine refrigerators and water pack freezers, rather these could remain connected to the reliable mains and facility back-up generator. However, to assure continuous electricity for the ULT freezers a back-up generator dedicated to the ULT freezers may be considered.

**d. Electricity supply assessment:** Multiple technical and administrative staff characterize the electricity supply as “normally” very reliable with rare short outages that are overcome with the back-up generator. However, both windstorms and floods have caused prolonged power outages reported by several long-term staff members to be of four days. During that time power and fuel deliveries were disrupted.

**e. Back-up power assessment:** A five-year-old diesel generator rated at 100 kVA is operable and appears to be well maintained. Fuel capacity is presently three days.

Note: since flooding is a threat and the fuel supply may not be adequate any solution relying on the generator will be improved if the fuel capacity is increased.

**f. Spare parts:** All essential generator spare parts are stocked as are replacement circuit breakers.

**g. Response time for repairs:** On-site staff are trained and able to carry out minor repairs of both the facility electrical distribution system and the back-up generator. However, major repairs require either the electric company technician or a contracted generator specialist. Facility staff noted that in the past most major repairs are carried out within 72 hours after first reported.

**h. PQS compliance requirement recommendations:**

- i. ULT vaccine freezer and ULT coolant pack freezer to comply with **WHO PQS E003/ULT** specifications.
- ii. Addition of vaccine refrigerator to comply with **WHO PQS E003/RF03** and voltage stabilizer to comply with **WHO PQS E007/VS**.

- iii. Each ULT vaccine freezer require a UPS complying with **WHO PQS E003/POW**.
- iv. All ULT freezers must be located in a dedicated room with mechanically cooled air set at + 25°C to assure thermal performance.
- v. Continuous power system to comply with **WHO PQS E003/POW**.
- vi. Continue to rely on mains power for existing and proposed new ULT freezer system loads (final design to determine if adequate mains electrical service capacity is available to add the new ULT freezer system loads).
- vii. Options for continuous electricity back-up include either:
  - (1) increasing the fuel capacity of the existing back-up generator to a minimum of 4 days to overcome historic power outages and fuel supply disruptions due to natural causes (final design to determine if adequate mains and generator capacity is available to add the new ULT freezer system loads); or
  - (2) add a dedicated back-up generator sized with capacity to power the ULT freezers and recharge the UPS battery. Include a dedicated fuel tank with a minimum of 4 days of fuel storage.

### **Abbreviated Example 2: Unreliable electricity (similar solutions for limited and no electricity)**

When the electrical supply is often interrupted and/or experiences prolonged outages it cannot be considered sufficiently reliable to sustain the required ULT freezer system. In such a case these sites will need to be equipped with two reliable sources of electricity. Typically, this will be a prime power generator with an equal back-up generator. The unreliable mains electric supply can still be used to reduce generator run time, but it cannot be considered as one of the required electric supply sources.

A similar power supply situation is found when there is no electricity or limited electricity (e.g. site where a generator operates for less than 24 hours daily or capacity is insufficient to add ULT freezer systems loads). As with unreliable electricity the solution will need to provide two reliable sources of electricity.

The example that follows is abbreviated with notes that indicate fictitious findings for key aspects of a site assessment along with notes and suggestions based on the information provided. Multiple solutions for supplying continuous electricity will be possible and this example portrays one possible approach to the conditions noted.

- a. **Location/contact information:** Typical inputs for location and contact persons information must be input by the site assessor.
- b. **Advance planning:** Due to the eight-hour travel time distance from the nearest major city to the facility site and limited electrical supply outlets near the facility the

installation of new equipment will require careful advance planning to assure all necessary equipment and supplies and workers are on site at time of installation.

Note: Facility is located in an urban area with shading from adjacent buildings that would severely limit solar energy applications.

- c. Climate factors:** Ambient temperatures average +25°C and range from an average monthly low of +5°C to an average monthly high of +32°C. Record high temperature was +38°C. Source of temperature data was supplied by the local weather station.

**d. CCE inventory (abbreviated to include only CCE in support of ULT freezer system)**

i. Vaccine refrigerator(s):

(1) Existing: 1 ice lined combined refrigerator water-pack freezer PQS code xxx

(2) existing: Voltage stabilizer for ice lined appliance PQS code xxx

(3) Planned: 1 identical to be added with voltage stabilizer

ii. Water pack freezer(s):

(1) Existing: 0

(2) Planned: 0

iii. ULT vaccine freezer(s):

(1) Existing: 0

(2) Planned: 1 ULT vaccine freezer PQS code xxx

iv. ULT coolant pack freezer(s):

(1) Existing: 0

(2) Planned: 1 ULT coolant pack freezer PQS code xxx

- e. Proposed ULT freezer locations(s):** All ULT freezers and supporting CCE must be located in a dedicated room with no mechanical cooling. Candidate rooms were inspected and all found to be adequate and secure.

Note: Room 108 is located on an interior plaza and is built of thick masonry construction with good ventilation and no solar heat gain. Staff confirmed that this room remains cooler than other candidate rooms.

- f. Freezer position infrastructure:** All candidate rooms have a single ceiling mounted 20-Watt fluorescent light and a single 230 Vac, 10-amp electric receptacle. Existing panel box has all circuit breaker positions used. Retrofit wiring can be observed in multiple locations and appears to have been added at different times and with different quality standards. No immediate safety concerns were observed.

Note: Added electrical capacity will be needed since the circuit breaker panel is fully utilized and a single 10-amp receptacle will be inadequate.

- g. Electricity supply assessment:** Unreliable and limited. The electricity supply assessment is based on anecdotal staff reports that the mains electricity is erratic with frequent outages (up to six per day) and prolonged outages of one day and longer. The operating hours of the generator are limited to a maximum of 10 hours per day due to budget constraints. This strategy is reported to sufficient to sustain the operation of the ice lined combined refrigerator water-pack freezer.
- h. Back-up power assessment: A 10-year-old diesel generator rated at 50 kVA is operable.** Staff report that they must disconnect or delay use of certain high demand loads during generator operation. Fuel capacity is presently two days.

Note: It would require a full facility energy audit to determine the generator capacity capable of sustaining all facility loads plus new ULT freezer system loads. A full energy audit is not within the scope of the site assessment and will require additional professionals.

- i. Spare parts:** Limited generator spare parts are stocked as are replacement circuit breakers.
- j. Response time for repairs:** Generator support is contracted only as required. Nearest contractor is based in the regional center located eight hours from the health facility. Emergency repair visits were reported to require at least 12 hours and sometimes were not possible in less than 24 hours. Maximum repair service completion was reported by staff to be seven days due to lack of spare parts.

**i. PQS compliance requirement recommendations:**

- i.** ULT vaccine freezer and ULT coolant pack freezer to comply with **WHO PQS E003/ULT** specifications. Assure that the appliance selected is rated to operate in ambient air temperatures up to +32°C.
- ii.** Addition of combined vaccine refrigerator water pack freezer to comply with **WHO PQS E003/RF03** and voltage stabilizer to comply with **WHO PQS E007/VS**.
- iii.** ULT vaccine freezer requires a UPS complying with **WHO PQS E003/POW: 0.1**.
- iv.** ULT freezers must be located in Room 108 (reported as coolest candidate room).
- v.** Continuous power system to comply with **WHO PQS E003/POW: 0.1**.
- vi.** Do not rely on existing mains power or existing back-up generator for proposed new ULT freezer system loads. The mains is considered unreliable and the existing electrical infrastructure and back-up generator limit the addition of new loads.
- vii.** Options for continuous electricity include either:
  - (1) Add two generators exclusively dedicated to the ULT freezer system loads. Provide all new wiring from generators to room 108. Include

all essential spare parts and consumables. Install fuel capacity of seven days to overcome long repair delays.

- (2) Add two generators exclusively dedicated to the ULT freezer system loads. Professionally assess the possibility of increasing mains capacity to opportunistically reduce generator operation (e.g. either add a separate and new mains service coupled with the generator system or increase the capacity of the existing mains service to allow addition of new ULT freezer system loads). Provide all new wiring to room 108. Install fuel capacity of seven days to overcome long repair delays.

**Additional recommendations:** Consider negotiating an optional extended service warranty for the UPS and generators to reduce repair response time and possibly reduce fuel storage capacity.

<b>Revision history</b>			
<b>Date</b>	<b>Change summary</b>	<b>Reason for change</b>	<b>Approved</b>