



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

<i>Product verification protocol:</i>	E003/POW VP- 01.0
<i>Product specification:</i>	E001/PVAC 01
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**Contents**

**1. Scope.....1**

**2. Terms and definitions.....3**

**3. Normative references .....5**

**4. Applicability.....6**

**5. Sample-examination checklist.....7**

5.1 Evidence of conformity assessment .....7

5.2 Samples and supporting material .....7

    5.2.1 *Generator sizing*.....7

    5.2.2 *UPS sizing* .....8

    5.2.3 *Equipment and Accessories*.....8

    5.2.4 *Photographs* .....9

    5.2.5 *Instructions*.....9

5.3 Test 1 - type-examination .....9

5.4 Criteria for qualification.....9

**Annex 1 – Compliance checklist .....10**

**Annex 2 – Generator sizing example .....15**

**Annex 3 – UPS sizing example .....17**

**Revision history .....19**

**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 Power systems for ultra-low temperature freezing systems** is an equipment 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 0.2 Power systems for ultra-low temperature freezing systems-** quality assurance protocol for specific [installation](#) requirements.

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.
- **WHO PQS E001/PVAC 01**, to which it refers.

## 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), uninterruptable 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 1 outage per month of less than one-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/ULTF.

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 electricity: 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 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**

Type-examination will be carried out by an [independent evaluator](#), appointed by WHO. The extent of the geographical limits of any grant of prequalification status will be reviewed and

decided upon by WHO.

## 5. Sample-examination checklist

### 5.1 Evidence of conformity assessment

Key components must carry the CE mark and/or equivalent internationally accepted evidence of conformity assessment.

### 5.2 Samples and supporting material

The [legal manufacturer](#) or [reseller](#) must supply the [independent evaluator](#) with a full duplicate set of the Product Dossier already supplied to WHO in accordance with the requirements of specification Clause 7, together with the following:

#### 5.2.1 *Generator sizing*

The [independent evaluator](#) will provide the [legal manufacturer](#) or [reseller](#) all [site assessment](#) details necessary for [legal manufacturer](#) or [reseller](#) to complete a fully worked example of a [continuous electricity](#) power system including [generator](#) sizing and major power system component sizing.

Example to include a calculation to estimate the [design day](#) requirements for all [load\(s\)](#) included and at a specified location. The example to include confirmation of the model(s) of PQS prequalified [ULT freezer\(s\)](#) and other [load\(s\)](#) included as part of a complete [ULT freezer system installation](#).

The [generator](#) sizing example to clearly indicate:

- [ULT freezer](#) Identification and PQS code number;
- [ULT freezer](#) electrical input specification;
- Site elevation;
- Site ambient temperature data;
- [ULT freezer](#) operating environment temperature range;
- [ULT freezer](#) electricity consumption at [legal manufacturer](#)-specified ambient temperature;
- UPS [battery charger](#) input power;
- Other loads (lighting, air conditioner, etc.);
- [Generator prime power rating](#);
- [Generator output voltage and frequency](#);
- [Generator controller type](#);
- [Generator fuel type](#);
- [Generator fuel consumption](#);
- [Stored fuel capacity](#);
- [ATS time startup and connect generator](#); and
- [Generator sizing calculations](#).

Attach specification sheets for [ULT freezer](#) and generator.

### 5.2.2 UPS sizing

The [legal manufacturer](#) or [reseller](#) to complete a fully worked example of a UPS sizing based on a WHO PQS prequalified ULT freezer per **WHO PQS E003/ULT01.0 Vaccine ultra-low temperature freezer: compression-cycle**. The energy consumption of the [ULT freezer](#) is to be based on the [legal manufacturer](#) specifications and at a minimum must include the Watt hours/day and the operating ambient temperature at which the Watt hours/day are based on.

The **UPS** sizing example to clearly indicate:

- [ULT freezer](#) identification and PQS code number;
- [ULT freezer](#) electrical input specification;
- Site ambient temperature data;
- [ULT freezer](#) operating environment temperature range;
- [ULT freezer](#) electricity consumption at [legal manufacturer](#)-specified ambient temperature;
- Type of **UPS** (single conversion or double conversion);
- [Battery charger](#) specifications (input voltage and frequency, output voltage, input current, output current);
- [Inverter](#) specifications (input voltage and frequency, output voltage and frequency, input current, continuous watt output at [ULT freezer](#) ambient temperature);
- *OR* [inverter/charger](#) (input **AC** voltage and frequency, output **AC** voltage and frequency, nominal **DC** voltage, input **AC** current, input **DC** current, output **DC** current, continuous watt output at [ULT freezer](#) ambient temperature, current rating of ATS, ATS transfer time for mains to [inverter](#) and [inverter](#) to mains);
- Battery specifications (quantity, series/parallel configuration, battery voltage and amp hours, battery bank voltage and amp hours discharge at specified capacity hours and temperature and final voltage per cell);
- Battery depth of discharge (not to exceed battery manufacturer recommendations);
- **UPS** electrical input and output specifications;
- **UPS** continuous output in watt at specified temperature; and
- Battery capacity calculation for a continuous eight-hour output including derating factors (e.g. operating temperature, aging).

Attach specification sheets for [ULT freezer](#) and **UPS** (including inverter/charger and battery).

### 5.2.3 Equipment and Accessories

For a typical continuous power system supplied, the [legal manufacturer](#) or [reseller](#) must confirm the type(s) and quantities of typical equipment, spare parts, supplies, consumables and accessories included and specify if employer is to supply additional accessories. Use **Annex 1** Compliance checklist to document compliance to **WHO PQS E003/POW: 0.1**.

#### 5.2.4 *Photographs*

Detailed high-resolution digital images of the [UPS](#), [generator\(s\)](#), battery, [inverter](#), [hybrid solar power system](#) (if included) and related system components in jpeg format.

#### 5.2.5 *Instructions*

[Legal manufacturer](#) or [reseller](#) to supply a sample of the instructions in the English language and as specified in **WHO PQS E003/POW: 0.1** Clause 4.11.

### 5.3 Test 1 - type-examination

- **Step 1:** Complete the compliance checklist in **Annex 1**. Record general comments and recommendations for each section.
- **Step 2:** Complete the generator sizing in Clause 5.2.1, the UPS sizing in Clause 5.2.2 and supply information per Clauses 5.2.3, 5.2.4 and 5.2.5.
- **Step 3:** Obtain any additional supporting information required [in writing](#) from the [legal manufacturer](#) or [reseller](#) and attach this information to the report.

**Acceptance criteria:** Inspection of Compliance checklist indicates full conformity with all major specification requirements and acceptable generator and UPS sizing submissions.

### 5.4 Criteria for qualification

A final report must be issued after the type-examination is complete. The report must contain the following data and analyses:

- **Summary:** Conclusions and recommendations.
- **Compliance checklist:** Completed **Annex 1** checklist.
- **Generator and UPS sizing:** Acceptable submissions per Clauses 5.2.1 and 5.2.2.
- Information provided is complete per Clauses 5.2.3, 5.2.4 and 5.2.5.
- **Photographs:** Submitted photographs as listed in Clause 5.2.4.
- **Annexes:** Additional supporting documentation requested and received from the [legal manufacturer](#) or [reseller](#) during the course of the type examination.

1

**Annex 1 – Compliance checklist**

Specification clause	Item		
<b><i>A. General information:</i></b>			
7.	Dossier fee received:	Yes	No Part payment
7.	Type-examination fee received:	Yes	No Part payment
7.	System identification: Code: Model:		
4.2.4	ULT Freezer(s) offered (include PQS code)		
7.	Legal manufacturer details: Name: Address 1: Address 2: Address 3: Address 4: Tel: Fax: Email: Web:		
7.	Reseller details: Name: Address 1: Address 2: Address 3: Address 4: Tel: Fax: Email: Web:	Applicable	Not applicable
4.1.1	Status:	Legal manufacturer	Reseller
4.1.2	Countries/regions where support services can be offered:		
<i>General information comments:</i>			
<b><i>B. Technical details (assumes example site assessment complete per Clauses 4.1.8 and 4.1.9):</i></b>			
4.1.3	Continuous power sizing per site assessment.	Not applicable	
4.1.3	Determination of AC electricity supply.	Not applicable	

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1 This is a Word 'Form' document. It needs to be copied and 'protected' before it can be used for data entry. Then activate View/Toolbars/Forms and click the 'lock' icon on the Forms toolbar. See also Word Help. Margins can be adjusted so form fits on a single page.

4.1.4, 4.1.5, 4.1.6 or 4.1.7 Note: if “no electricity” solution includes a hybrid solar power system also complete E001 PVAC VP0.1.	General system design (note supply availability type).	Not applicable	
<i>Comments on availability and continuous electricity system solution: Not applicable to VP0.1.</i>			
4.2.1	Uninterruptible power supply (UPS).	Conforms to specification?	Yes No
4.2.1	UPS type (note if single or double conversion).	Conforms to specification?	Yes No Type: _____
4.2.1.1	UPS sizing.	Conforms to specification?	Yes No
<i>Comments on UPS sizing per Clause 5.2.2 of this document including: Identification of ULT freezer and PQS code number, temperature of operating environment, electricity consumption at specified temperature, battery capacity calculation including maximum battery depth of discharge and battery recharge time.</i>			
4.2.1.2	UPS battery.	Conforms to specification?	Yes No
4.2.1.2.1	Battery type.	Conforms to specification?	Yes No
4.2.1.2.2	Battery set sizing.	Conforms to specification?	Yes No
4.2.1.2.3	Battery set housing.	Conforms to specification?	Yes No
4.2.1.2.4	Battery safety kit.	Conforms to specification?	Yes No
4.2.1.3	UPS charger.	Conforms to specification?	Yes No
4.2.1.4	UPS inverter.	Conforms to specification?	Yes No
4.2.1.5	Transfer switch (note type(s)).	Conforms to specification?	Yes No Type(s) _____ _____
4.2.1.6	Disconnects.	Conforms to specification?	Yes No

4.2.1.7	Monitoring and alarms.	Conforms to specification?	Yes No
<i>Comments on UPS system:</i>			
4.2.2	Generator.	Conforms to specification?	Yes No
4.2.2.2	Generator type (note: fuel and type).	Conforms to specification?	Yes No Fuel: _____ Type: _____
4.2.2.3	Start-up time.	Conforms to specification?	Yes No
4.2.2.4	Transfer switches (note type(s)).	Conforms to specification?	Yes No Type(s) _____
4.2.2.5	Generator sizing.	Conforms to specification?	Yes No
<i>Comments on generator sizing: per Clause 5.21 of this document including: Identification of ULT freezers, PQS code number, other ULT freezer system loads, temperature of operating environment, elevation, fuel capacity estimation and electricity consumption at ambient operating temperature.</i>			
4.2.2.6	Paralleled generators.	Conforms to specification?	Yes No Not applicable
4.2.2.7	Generator requirements.	Conforms to specification?	Yes No
4.2.2.8	Earthing.	Component weights comply?	Yes No
4.2.2.9	Starting system.	Conforms to specification?	Yes No
4.2.2.10	Stored fuel capacity and fuel tank.	Conforms to specification?	Yes No
4.2.2.11	Monitoring and alarms.	Conforms to specification?	Yes No
4.2.2.12	Accessories.	Conforms to specification?	Yes No
4.2.2.13	Generator installation.	Conforms to specification?	Yes No
4.2.2.14	Operations manual.	Conforms to specification?	Yes No
4.2.2.15	Spare parts.	Conforms to specification?	Yes No

<i>Comments on generator system:</i>			
4.6.2	Safe access.	If observed, conforms to specification?	Yes No
4.7.1	Restricted materials.	Conforms to specification?	Yes No
4.8	Warranty.	Conforms to specification?	Yes No
4.9.1	Servicing provision.	Conforms to specification?	Yes No
4.9.2	Spare parts, supplies.	Conforms to specification?	Yes No
4.10	Disposal and recycling.	Conforms to specification?	Yes No
4.11	Instructions.	User instructions conforms to specification?	Yes No
		Installer instructions Conform to specification?	Yes No
4.11	Sample manual(s).	Is it satisfactory?	Yes No
4.12	User training.	Conforms to specification?	Yes No
5.	Packaging.	Conforms to specification?	Yes No
<i>Additional technical comments:</i>			
<b><i>C. Norms and standards:</i></b>			
6.	On-site installation.	Offered?	Yes No
7.	List of installations:	Details supplied: Satisfactory?	Yes No
7.	Environmental audit scheme.	Type: Current? (Note: not mandatory)	Yes No
7.	Laboratory test reports or declarations.	Details: Satisfactory?	Yes No
7.	Type approval details.	Details supplied: Satisfactory?	Yes No

7.	Current ISO 9001 certification.	Conforms to specification?	Yes No. Or Pending
8.	On-site maintenance service (optional).	Offered?	Yes No
<i>Norms and standards comments:</i>			
<b><i>D. Conclusions:</i></b>			
Overall summary:			
		<b>DECISION:</b>	Prequalify?
		<b>QA Assessor</b>	Reject?
		<b>Contact info</b>	

## Annex 2 – Generator sizing example

(see Clause 5.2.1)

Each manufacturer or reseller seeking prequalification as a supplier of **continuous electricity** for a **ULT freezer** will be required to submit one completed sizing example for the **generator** coupled to a specified prequalified WHO PQS prequalified **ULT freezer** and additional **ULT freezer** system **loads**. The details of this fictitious example are to be provided by the **quality assessor**. The example may be submitted on the form as shown in this **Annex 2** or by other means with equal clarity of information.

The minimum detail required will be a fully worked example of the **generator** sizing including a fuel storage capacity calculation for the specific WHO PQS prequalified **ULT freezer** per **WHO PQS E003/ULT0.1 Vaccine ultra low temperature freezer: compression-cycle** and the **continuous electricity** system per **WHO PQS E003/POW0.1 Power systems for ultra-low temperature freezing systems**.

The **generator** sizing example to clearly indicate:

- **ULT freezer** Identification and PQS code number;
- **ULT freezer** electrical input specification;
- **ULT freezer** operating environment temperature range;
- **ULT freezer** electricity consumption at **legal manufacturer**-specified ambient temperature;
- Elevation (used for sizing example)
- UPS battery charger input power;
- Other loads (lighting, air conditioner, etc.);
- **Generator prime power rating**;
- **Generator output voltage and frequency**;
- **Generator controller type**;
- **Generator fuel type**;
- **Generator fuel consumption**;
- **Stored fuel capacity**;
- **ATS time startup and connect generator**; and
- **Generator sizing calculations**.

Attach specification sheets for **ULT freezer** and generator.

### Generator sizing example:

<b>ULT freezer</b> Quantity = 2 (1 for vaccine, 1 for ULT coolant freezing)	Mfc = ABC Ltd 230 Vac, 50 Hz	Model = ULT-86C 1000 watt/freezer 10,000 Wh/day @ +25°C	PQS code = E003/tbd Ambient operating temperature range Max = +25°C Min = -10°C
<b>Additional loads:</b> Quantity x watt	Air Conditioner 1 x 1500W	Lighting, office loads 500W	UPS battery charger 1 x 4000W
<b>UPS:</b> Quantity = 1 (for vaccine freezer)	Model = I-230v/1200	Output 1200 watt continuous	Battery charger max input power = 4000W
<b>Generator:</b> Quantity = 1	Mfc = ABC Co.	Model = GXX230V/12K	Capacity: 12,000W
<b>Fuel:</b> Rate @ 100% load Rate @ 25% load	Diesel 100% = 3 L/h 25% = 1 L/h	Fuel capacity (min) = 72 hr x 3 l/hr = 216 liters	Fuel tank capacity = 250 gallons
<b>Location (example):</b>	Average air temperature = +30°C	Elevation = 1000 M	

### Generator system calculations:

- **Design day assumptions:** Location ambient can exceed +30°C therefore the freezers are to be located in air-conditioned space. ULT freezers and freezer system loads all to operate continuously at total connected watt in an air-conditioned room at +25°C.
- **Load** (total connected watt) = (2 x 1000 W ULT freezers + 1 x 4000 W battery charger + 1500 W AC + 150 W lights + 350 office equipment) = 8000 W total connected load.
- **Generator capacity** = 8000 W total load / 0.9 temperature derate / 0.95 altitude derate / 0.8 spare capacity = 11,696 W at total load or 12 kVA.
- **Fuel capacity** (minimum of three-day fuel storage capacity) = 3 Litre/h x 72 hours = 216 Litre of diesel fuel

## Annex 3 – UPS sizing example

(see Clause 5.2.2)

Each [legal manufacturer](#) or [reseller](#) seeking prequalification as a supplier of [continuous electricity](#) for a [ULT freezer](#) will be required to submit one completed sizing example for the [uninterruptible power supply \(UPS\)](#) coupled to a specified prequalified WHO PQS prequalified [ULT freezer](#). The example may be submitted on the form as shown in this **Annex 3** or by other means with equal clarity of information.

The minimum detail required will be a fully worked example of the [UPS](#) sizing including a battery capacity calculation for the specific WHO PQS prequalified [ULT freezer](#) per **WHO PQS E003/ULT0.1 Vaccine ultra-low temperature freezer: compression-cycle**.

The [UPS](#) sizing example to clearly indicate:

- [ULT freezer](#) identification and PQS code number;
- [ULT freezer](#) electrical input specification;
- [ULT freezer](#) operating environment temperature range;
- [ULT freezer](#) electricity consumption at a manufacturer-specified ambient temperature;
- Type of [UPS](#) (single conversion or double conversion);
- [Battery charger](#) specifications (input voltage and frequency, output voltage, input current, output current);
- [Inverter](#) specifications (input voltage and frequency, output voltage and frequency, input current, continuous watt output at [ULT freezer](#) operating ambient temperature);
- Or [inverter/charger](#) (input [AC](#) voltage and frequency, output [AC](#) voltage and frequency, nominal [DC](#) voltage, input [AC](#) current, input [DC](#) current, output [DC](#) current, continuous watt output at [ULT freezer](#) operating ambient temperature, current rating of [ATS](#), [ATS](#) transfer time for mains to [inverter](#) and [inverter](#) to mains);
- Battery specifications (quantity, series/parallel configuration, battery voltage and amp hours, battery bank voltage and amp hours discharge at specified capacity hours and temperature and final voltage per cell);
- Battery depth of discharge (not to exceed battery manufacturer recommendations);
- Battery recharge time;
- [UPS](#) electrical input and output specifications;
- [UPS](#) continuous output in watt at specified temperature; and
- Battery capacity calculation for a continuous eight-hour output.

Attach specification sheet for [ULT freezer](#) and [UPS](#) (including inverter/charger, battery).

### UPS Sizing Example:

<b>ULT vaccine freezer:</b>	Mfc = TTT Ltd.	Model = -70C	PQS code = E003/tbd
Quantity = 1	230 Vac, 50 Hz	1000 watt	
<b>UPS:</b>	Mfc = UPS Ltda.	Model = W1500	Type: Single conversion
Quantity = 1	Output (cont.) = 1500 W @ +25°C	Battery capacity = 8 hours	Features: ATS, TC
Specifications	230 Vac, 50Hz input 230 Vac, 50Hz output	Battery charger: 48 Vdc, 30 amps Output = 3000 Watt for 5 seconds @ 25°C	ATS: 15A, transfer time <5ms mains to inverter, <7ms inverter to mains
<b>Battery:</b>	Mfc = BATS Inc.	Model = 12-430	
Quantity = 4	4 series x 1 parallel	12 Vdc, 430 Ah = 48 Vdc, 430 Ah @ C/8 hours @ +25°C to 1.75 Volts per cell	Maximum depth of discharge = 80%
<b>Location:</b>	Min. operating temp. = +10°C	Freezer ambient air temperature = +25°C	Battery storage area ambient air = +32C

- **Location assumptions:** ULT freezer to operate in a +25°C room. Battery to be placed in an area that will be +32°C.
- **Battery calculation:** (1000-Watt ULT load x 8 hours) / 48 Vdc / 0.6 DOD / 0.9 inverter efficiency / 0.9 temperature derate / 0.8 ageing factor = 429 AH battery at 48 Vdc
- **Battery recharge time calculations:** (429 Ah battery x 0.6 DOD) / 0.9 battery inefficiencies / 30 A = 9.5 hours

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