

UPS (Un-interruptible power supply)

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1.0 INTRODUCTION

Specification is related to the 1500 TPD concentrator for a polymetallic ore located in Bolnisi Georgia. The present technical sheet covers the specifications for UPS.

2.0 PROJECT GENERAL DATA

- Mining method : Underground.
- Process type: Flotation.
- Ore type: Polymetallic ore.
- Location: Bolnisi - Georgia (Eastern Europe).

3.0 SCOPE

This document establishes the technical requirements for the design, manufacture and testing of continuous duty, three phase solid-state UPS.

4.0 Standards and regulatory documents

UPS and its integral components and materials shall comply with the requirements of IEC standards. Compliance with this specification does not release the Vendor from responsibility to supply properly designed equipment, mechanical and electrical parameters of which are designed for the specified operation conditions and maintenance at construction site.

5.0 Foreign and international standards

EN 50091 Uninterruptible Power Systems (UPS)

IEC 62040 Uninterruptible Power System (UPS)

IEC 60146 Semiconductor converters

IEC 60269 Low-voltage fuses

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 60085 Thermal evaluation and classification of electrical insulation

IEC 60076: Power Transformers

IEC 61439: Low-voltage switchgear and controlgear assemblies

IEC61557-14: Electrical safety in low voltage distribution systems up to 1 000 V a.c
and 1 500 V d.c.

6.0 Design basis

The design of the UPS shall be such as to minimize the risk of short circuits and shall ensure personnel and operational safety. The electrical load to be energized by the UPS comprises a high proportion of digital electronic equipment incorporating switched-mode power supply units, which exhibit non-linear characteristics. All components shall be of a quality and reliability that satisfies the requirements of a secure AC source of power to vital equipment performing a controlling, monitoring and safeguarding function in continuously operating petrochemical process units, production facilities and utility installations.

Parallel redundant static UPS unit: A parallel redundant system as shown in figure 2 shall comprise at least two UPS modules, which are paralleled at the output. This allows a significant increase of the system's availability and improves the total power capability in regard to overloads and short circuits. Both UPS modules shall have the same priority and are equally sharing the total load while 50 % of the nominal power rating of either unit shall not be exceeded. A common by-pass source is distributed to the two static bypass switches and can be routed directly to the load by means of the manual "make before-break" switch. A common battery bank is possible, but individual battery banks are preferable (i.e. 2 x 100 % or 2 x 50 % capacity).

OPERATION MODES

Normal operation - Each part of the overall system is available with any power sources in tolerance. Both, rectifiers and inverters units are sharing the total output power. By-pass source is standby and acting as synchronization source.

Power failure on one module - This particular UPS module switches to stand-by operation while the other one will carry the full load. No power re-routing by means of switches is required. This mode also preserves the battery power for as long as possible. **Power failure on both modules** - Both modules call up battery operation simultaneously and discharge the battery banks equally yet still delivering 50 % of the total output power. Co-ordinate changeover to bypass takes place if the battery capacity is completely used up.

System fault on one module - The failed module is immediately set to stand-by mode while the remaining one takes the full load without disturbing it. **Overload condition** - Both modules are capable to continuously supply 100 % of their nominal rating which equals to 200 % overall power performance. In case this value is exceeded and the load goes beyond the given overload profile, an uninterruptible transfer to by-pass mains would occur by closing both static bypass switches simultaneously.

Tie-In of UPS Unit to Electrical Supply System

The Manufacturer shall specify the current rating of the circuit breaker, which the Owner shall provide in the mains supply switchboard for energizing the rectifier and by-pass circuits. All batteries should be located in a suitable cabinet separate from the UPS. The Manufacturer shall specify the size of the conductors required for the battery cables, based on a cable length not exceeding 20 m. The Manufacturer shall provide a suitable, lockable, fused load-switch or MCCB to facilitate on-load isolation of the battery for the purpose of performing battery maintenance. The switching device should be installed adjacent to the battery, outside battery room near door. If the nominal output voltage of the UPS and/or the neutral earthing scheme is different from that of the mains supply, the Manufacturer shall provide an isolation transformer in the by-pass circuit (by-pass transformer). For single-phase UPS units the transformer shall be connected across two phases of the three-phase supply. Phase equalizing transformers should be used for single-phase UPS ratings above 40 kVA, which are connected to three phases. The secondary neutral of the transformer shall be earthed unless otherwise specified.

7.0 PERFORMANCE REQUIREMENTS

Rectifier - 6 or 12 pulse heavy-duty thyristor rectifier bridges shall be used to convert the 3-phase AC input to DC. On the Owner's request an isolation input transformer shall be applied for best immunity to mains disturbance and galvanic isolation to the DC branch. The rectifier shall operate according to the constant voltage, current limiting principle (IU characteristic) and shall incorporate a softstart feature to gradually accept load on initial energizing. The rectifier shall restart automatically upon restoration of the mains power supply following a supply interruption with a programmable delay for coordinated start-up. The rectifier shall be rated to recharge the battery to 90 % within 10 hours following a discharge at rated load for the specified autonomy time, while at the same time meeting the inverter input requirements when the inverter is delivering its rated output at 0.8 power factor (inductive). For maintenance free batteries, the rectifier shall perform battery charging in accordance with the operational stipulations of the battery supplier and high rate charge facilities shall be interlockable. The UPS unit shall be capable of operating from the mains electricity supply. The total harmonic current consumption shall not exceed 28 % of the fundamental current for 6 pulse and 12 % for 12 pulse configurations. Lower values, if specified by the Owner, shall be achieved by adding a passive filter at the mains input. Transients and surges on the mains input shall not result in a trip of the rectifier unit or the initiation of battery discharge. The superposed AC ripple voltage on the DC terminals shall not exceed 1 % of the nominal DC level at full load conditions with no battery connected. The residual ripple current in the battery circuit shall not exceed 5 % of the C10 capacity for batteries. Battery float-charge operation: The

rectifier steady-state DC output voltage variations shall be within less than plus and minus 1 % of the set value of the temperature compensated battery float charge voltage specified by the battery Manufacturer during load variations between zero and the rated output of the rectifier. This shall be achievable throughout the range of steady-state input voltage and frequency. The instantaneous value of the output voltage shall not deviate by more than 10 % at load steps from 10 to 100 % or 100 to 10 % with a regulation time of less than 500 ms to ± 1 %.

Battery and DC circuit

The batteries shall be sealed, maintenance free lead batteries. The manufacturer shall define the battery characteristics, in particular the number of elements, the rated capacity and the discharge cell voltage, taking into account the storage energy requirement. The battery voltage and capacity shall be such as to fulfill the inverter input power requirements when the inverter is delivering its rated kVA output for 30 minutes at specified power factor, for the times specified in the requisition. The nominal ampere-hour (Ah) capacity of the battery supplied with the UPS shall be calculated in line with a battery Manufacturer's approved method and shall include all necessary allowances as

specified in the datasheet, required to compensate ageing effects that result in the progressive loss of capacity.

Sealed, maintenance free lead storage batteries shall be housed in freestanding cabinets to be located adjacent to UPS. Battery cabinets shall be designed to provide easy accessibility of the batteries.

All UPS units shall be provided with online battery discharge test facility, which keeps the rectifier on stand-by for immediate restoration in case of fatal battery failure. The UPS shall also provide an on-line battery testing by means of a partial battery discharge into the load (typically 25 %), either manually or automatically. The facility shall be programmable to define the automatic testing periods. The monitoring system shall compare the actual discharge values with the pre-programmed battery discharge characteristics and shall be capable of providing a detailed analysis of the battery condition and indication of remaining back-up time. Additionally, provision shall be included to manually select a full battery discharge test.

Inverter

IGBT (Insulated Gate Bipolar Transistors) should be applied for the power stacks. The inverter shall be short circuit proven and have nominal output voltage and frequency as specified in the requisition. An isolation transformer shall provide galvanic isolation between the DC and AC power

circuits for best immunity to disturbance and to allow an isolated (unearthed) neutral output. The inverter output voltage and frequency shall not exceed the operational tolerances given below, as measured at the output terminals of the UPS unit, during the following conditions of UPS loading: Steady-state load variations between zero and the rated output of the UPS. Load power factors over the range 0.4 inductive to 0.9 capacitive within the kW/kVA rating of the UPS unit. The inverter shall be sized for unity power factor. Load current waveform having a relative harmonic content varying between 0 % and 50 %, the latter waveform having a crest factor up to 3.5. DC input voltages over the range corresponding to battery high rate charge, where applicable, and battery discharge operation during the specified discharge times. The inverter shall control the output of the UPS so as to maintain synchronism with the by-pass voltage during variations in mains frequency. During variations in mains frequency exceeding these limits, the inverter shall revert to internal frequency control.

The rated output of the UPS shall be as specified in the purchase order requirements.

The output voltage static regulation shall be maintained within plus and minus 1 % of rated output voltage. For 3-phase inverters, the phase-to-phase- and phase-to-neutral voltages shall not exceed ± 1 % of rated voltage when the load current in any two phases differs from the rated output current by up to 50 %. The dynamic output voltage variations shall not exceed ± 4 % of rated output voltage in the event of instantaneous load steps of 100 % rated output. The output voltage shall be restored to within the steady-state limits of ± 1 % of rated output voltage within 25 msec.

The waveform of the output voltage shall be sinusoidal with a relative harmonic content not exceeding 4 % for linear and 5 % for non-linear loads (according IEC 62040-3) with any individual harmonic < 3 %, unless otherwise is stated in the requisition.

For 3-phase inverters, the angular displacement of the phase voltages shall not exceed $120^\circ \pm 2$ % when supplying a balanced, linear load at rated output, 0.8 power factor inductive, and $120^\circ \pm 5$ % when the load current in one phase differs by 100 % from the rated output current.

As a minimum the inverter shall be capable of delivering the following short-circuit/overload levels based on the nominal rating: 200 % for 100 msec; 150 % for 1 min; 125 % for 10 min; 105 % continuously. For fuse keeping during excessive over loads the UPS unit may switch to bypass without interruption to the vital power, unless this is specified otherwise in the UPS data sheet. Over sizing of the inverter power stacks up to 400 % for 100 msec. shall be available if specified in the requisition.

By-pass circuit

The by-pass circuit shall be rated for at least the full UPS unit rating at continuous duty with the overload profile as specified in (3.3.8). Oversizing up to 200 % of the inverter rating shall be possible if specified in the requisition. The whole by-pass circuit except the static switch shall be segregated from the rectifier and inverter parts for the ease of safe access and maintenance. A dry isolation transformer with interwinding screen shall be applied to the by-pass circuit in case of unequal mains configurations and/or unequal voltage levels (by-pass mains input to UPS output). It is also required in case of different earthing schemes (IEC 62040-1-2). The short circuit impedance shall be less than 4 %. A servo controlled voltage stabilizer shall be applied in case of unstable or weak bypass mains. It shall provide galvanic isolation with a short circuit capacity of at least 1000 % for 100 msec. Static output voltage tolerance shall be less than ± 2 % with steady load variations between 0 % and 100 % of the bypass circuit rating in conjunction with mains voltage variations of ± 15 % from nominal value. The short circuit impedance shall be less than 6 %. Phase shift from input to output shall be zero.

The by-pass load transfer-switching device shall comprise a continuously rated thyristor switch. It shall have a current rating as specified previously and shall be short circuit proven to meet the following requirements.

Facilities shall be provided to initiate manually and automatically transfer of the load from the inverter supply to the bypass supply, and vice versa, without interruption of the vital supply. Load transfer shall only be possible when: The by-pass voltage is within ± 10 % of rated UPS output voltage; the by-pass frequency is within ± 6 % of rated frequency; the inverter output and by-pass voltages are synchronized. Automatic transfer of the load shall be initiated when: the inverter output voltage drops below 90 % of the nominal output voltage. Transfer should be accomplished before the voltage reaches 88 % of the nominal value; the inverter output voltage exceeds 110 % of the nominal output voltage. Transfer should be accomplished before the voltage reaches 112 % of the nominal value; the inverter output current limit is exceeded.

Load re-transfer shall be possible only when: the inverter output voltage is within ± 5 % of the nominal output voltage for more than 3 seconds; the inverter output and bypass voltages are synchronized; the fault which resulted in the initiation of the transfer has been cleared.

Maintenance by-pass switch

A manually operated make-before-break changeover switch in a segregated compartment shall be provided in order to by-pass the UPS power circuits (inverter and static switch) for maintenance and repair purposes. It should have three switching positions: “**Auto**”: Inverter is connected to the secured load bus with the static bypass energized for automatic transfer.

“**Test**”: Secured load bus is connected to the bypass circuit with the static switch circuit energized for synchronization tests.

“By-pass”: Secured load bus is connected to the bypass circuit with the static switch circuit isolated.

Electromagnetic compatibility (EMC)

All UPS units shall comply with the requirements for EMC as defined in IEC 62040-2,

UPS Unit Enclosure

The rectifier, inverter and static switch shall be installed in one or more freestanding, self-supporting steel cabinets forming an enclosure. Each cabinet shall be suitable for operation and maintenance with its rear panel against a wall and with similar cabinets located immediately on both sides.

Cooling

The unit shall be self-ventilated. The UPS unit shall be capable of continuously delivering its rated output, without switching to bypass mode under normal operating conditions, with any one forced air ventilation fan out of service (N+1 redundancy). Under the latter conditions, the maximum specified temperature of components shall not be exceeded. All fans shall be equipped with contactless monitoring facilities to provide an alarm in the event of fan failure and shall allow on-line replacement. 100 % redundant fans shall be provided if specified in the requisition.

Accessibility and Maintenance Safety

Items requiring access for maintenance such as cooling fans and filter capacitors shall be so located as to facilitate any required maintenance from the front of the unit. If rear access is required to carry out any form of maintenance this shall be clearly identified in the documentation. All live terminals of door-mounted equipment having a maximum voltage of greater than 60 V DC or 42 V AC shall be shrouded or otherwise protected by barriers to a degree of protection of at least IP21. The UPS enclosure shall have facilities for the entry of cables from top or bottom.

Battery construction and requirements

Inter-cell connectors and pillar terminals shall be insulated or otherwise provided with protective covering to prevent inadvertent short-circuiting. The battery cells shall be delivered filled and charged. There shall be clear instruction from the Manufacturer regarding storage and recharging requirement, if any, before use during commissioning. Batteries should be minor maintenance type, with at least 4 years interval between repairs. The technology of batteries status assessment in

operation should be provided, in order to define batteries prospect maintenance and residual life time.

MEASUREMENT, PROTECTION AND CONTROL EQUIPMENT

The UPS shall incorporate all the necessary equipment to enable operation, protection and control of the UPS in accordance with this specification, and to safeguard the unit and its components from the consequences of internal and external short circuits, overvoltage's and any power or control circuit malfunctions, howsoever caused. At least the following indications, in the form of LED/LCDs and/or measuring instruments, shall be provided on the front outside panel of the unit to enable verification of the operational status of the UPS. Indicators shall be superimposed on the UPS symbolic circuit:

- Rectifier input supply available
- Alternative/bypass supply available
- Rectifier on

- Battery operation
- Inverter on
- Load on inverter
- Load on static bypass
- Inverter/bypass synchronized
- Inverter output within tolerance
- Status of input-, battery- and output MCCBs or switches

The following data shall be provided on the front outside panel via a menu driven LCD display:

- Rectifier input voltage per phase
- Rectifier input current per phase
- Alternative/bypass voltage per phase
- Rectifier output current
- Battery charge and discharge current
- UPS output voltage per phase
- UPS output current per phase
- UPS output peak current per phase
- UPS output frequency
- Battery autonomy time remaining
- Battery temperature

The following alarm and protection functions shall be provided as a minimum:

- Rectifier input out of tolerance - alarm and trip rectifier
- Alternative/bypass voltage out of tolerance - alarm and trip static bypass
- Rectifier failure - alarm and trip rectifier
- D.C. overvoltage - alarm and trip rectifier/inverter
- D.C. under voltage - alarm and trip inverter
- Battery discharged - alarm only
- Battery disconnected - alarm only
- Inverter failure - alarm and trip inverter
- Inverter/static bypass overload - alarm only
- Bypass static switch inhibited - alarm and lock transfer
- Inverter static switch inhibited - alarm and lock transfer
- Inverter fuse failure - alarm and trip inverter
- Rectifier fuse failure - alarm and trip rectifier
- Inverter/bypass not synchronized - alarm only
- Individual fan failure - alarm only
- Magnetics/power module over temperature - alarm and delayed trip
- Fault in internal power supply - alarm only
- Load on maintenance bypass - alarm only
- Load feeders open or tripped - alarm only
- Earth fault on DC - alarm only

8.0 UPS MAINTENANCE

The Supplier will establish periodicity of UPS scheduled maintenance.