AFRY
ÅF PÖYRY

ELLOMAY
Pumped Storage (2014) Ltd.

PSPP MANARA

ISRAEL

Particular EM Specifications

Power Plant Equipment

Volume 2

Section VII

Part 3

Written:	Various	07.12.2020
Checked:	Schitter, Werner	10.12.2020
Approved:	Binder, Uri	15.01.2021

Doc.No.: **MANARA/TD/GS/01/002** App. Code: **A** Rev.:**2.1**

COMPOSITION OF RFP DOCUMENTS

Volume 0	**THE REQUEST FOR PROPOSALS**	
	Section I	Instructions to Participants
	Section II	Bonus Evaluation Criteria
	Section III	Bill of Quantities and Price Lists
	Section IV	Data Sheet
Volume 1	**THE CONTRACTS**	
	Schedule I	EPC Contract Agreement
	Schedule II	General Conditions of Contract
	Schedule III	Particular Conditions of Contract including Annexes
	Schedule IV	O&M Contract including Annexes
	Schedule V	EPC and O&M Interface Agreement
Volume 2	**SPECIFICATIONS**	
	Section I	Owner's Requirements
	Section II	IEC Conditions for connection of generation units to the grid
	Section III	Power Purchase Agreement (PPA) [Informal Translation]
	Section IV	General Civil Specifications
	Section V	Particular Civil Specifications
	Section VI	General EM, HM Specifications
	Section VII	Particular Electro-Mechanical Specifications
		Part 1 - Pumpturbine
		Part 2 - Motorgenerator
		Part 3 - Power Plant Equipment
	Section VIII	Particular Hydro-Mechanical Specifications
		Part 1 - Trash Racks and Bottom Outlets
		Part 2 - Intake Roller Gates and Stoplog Gates
		Part 3 - Penstock Steel Liner and Flexible Joints
	Section IX	Particular Switchyard / Control Building IEC Specifications
	Section X	Operation & Maintenance Specifications
	Section XI	Interface Guidelines (EPC - EM Sub - O&M)
	Section XII	O&M Organization Chart + Timeschedule Template
	Section XIII	Security Requirements for the Plant
Volume 3	**OUTLINE DESIGN (BASIC DESIGN))**	
	Section I	Reports
	Section II	Drawings
Volume 4	**SITE INFORMATIONS**	
	Section I	Geological Baseline Report

TABLE OF CONTENTS

REVISION NUMBER

1.0 First edition
2.0 Second edition
3.0 Implementing Voith Comments

1 GENERAL

Notwithstanding anything to the contrary in this document or any other Project Document, the Design and Works and Services (as applicable) shall be done and executed in compliance and shall adhere to the Israeli applicable standards. Compliance with an applicable recognized international standard shall not in no way derogate from the above requirement to comply at all times with the Israeli applicable standards. In the event that no Israeli standard is applicable the Design and Works and Services (as applicable) shall be done and executed in compliance and shall adhere to the relevant standard specified in the list included in the general specifications (Volume 2 Section IV, Section VI of the RFP Documents).

2 TRANSFORMERS

2.1 General Description

2.2 Scope of Supply

This Specification covers the design, manufacture, assembly, testing at the factory, and transportation from factory to site, storage, complete erection, field test and commissioning of the following equipment:

One (1) unit transformer, rated 265 MVA, three phase, three winding step-up type transformer unit, for indoor erection, mineral oil-immersed, ODWF or OFWF-cooled, 161 ± 7 x 1.0 % / 15.8[1] kV, complete with on-load tap changer, cooling equipment, online monitoring system and all required accessories.

Two (2) station service transformers in the powerhouse, rated 1600 kVA, three phase step-down type, for indoor erection, cast resin dry type, AN-cooled, 15.8 ± 2 x 2.5% / 0.4 kV, 50 Hz, complete with off-load tap changer and all required accessories.

Two (2) station service transformers in the powerhouse, rated 1600 kVA, three phase step-down type, for indoor erection, cast resin dry type, AN-cooled, 22 ± 2 x 2.5% / 0.4 kV, 50 Hz, complete with off-load tap changer and all required accessories.

One (1) station service transformers in the upper reservoir operating building, rated 160 kVA, three phase step-down type, for indoor erection, cast resin dry type, AN-cooled, 22 ± 2 x 2.5% / 0.4 kV, 50 Hz, complete with off-load tap changer and all required accessories.

Two (2) auxiliary transformers in the operating building and lower reservoir bottom outlet, rated 100 kVA, three phase step-up/down type, for indoor erection, cast resin dry type, AN-cooled, 0.95 (0.69) ± 2 x 2.5% / 0.4 kV, 50 Hz, complete with off-load tap changer and all required accessories.

2.3 Standards

The mechanical and electrical design of the transformers and their accessories shall strictly follow the IEC Recommendations

IEC 60076	Power transformers
IEC 60076-4	Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-10	Determination of sound levels
IEC 60123	Recommendations for sound level meters

[1] The voltage level on the LV side has to be coordinated with the generator supplier.

IEC 60137	Insulated bushings for alternating voltages above 1000 V
IEC 60156	Insulating liquids - Determination of the breakdown voltage at power frequency - Test method
IEC 60214	Tap-changers
IEC 60296	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear
IEC 60616	Terminal and tapping markings for power transformers

and shall be based on the following conditions and requirements stated under section 2.4 and 2.5.

2.4 Unit transformer

2.4.1 General description

There will be one (1) three phase step up transformer for energy evacuation to the 161 kV grid installed. On the LV side the connection will be made via metal enclosed isolated phase busducts. On the HV side the transformer will be directly connected to the respectively grid via underground cable connection.

The step up transformer will be installed in a separate transformer room.

2.4.2 Design particulars

The continuous rating when the forced water-cooling system is out of service shall be as high as possible for the economic considerations.

The no load excitation current shall be as low as possible for the economic considerations.

The winding of the transformer shall withstand mechanical and thermal stresses caused by short-circuit fault current stipulated in IEC 60076.

The transformer shall be designed to withstand, without injury, a voltage of 30% greater than the rated generator voltage, when the generator full load is rejected.

The transformers must be capable of continuous operation at the rated power of 265 MVA in the whole voltage control range of the generators 15.8 kV ± 6 % and the tapping range of the HV winding 161 kV ± 7 x 1.0 % without exceeding the rated temperature rise. The transformer shall be capable of continuous operation under frequency varying ± 3 % of rated frequency

The transformer shall to be designed for the corresponding lightning impulse withstand voltage according to IEC and the insulation coordination study. Additional overvoltage protection will be achieved by external surge arrestors which shall be located in very close proximity to the transformers.

Documentary evidence of such design shall be submitted to the Owner for comments and approval.

IECo approval is required for the unit transformers,.

2.4.3 Technical data

Number of units	1
Rated unit power	265 MVA
Type	3 phase oil-immersed unit
Number of phases-	3
Rated frequency	50 Hz
Short-circuit impedance	12.5%[2]
Tap changers on HV side, on-load	161 kV ± 7 x 1.0 %
Three phase vector diagram	YNd11
Neutral	solidly grounded
Cooling system	ODWF or OFWF
Cooling medium	Mineral oil
Noise level normal load	approx. 76 dB
Max. average sound level (at 2 m)	< 80 dB (A)
Max. temperature rise	
For oil (measured by resistance)	55 K
For winding (measured by thermometer)	60 K
Highest voltage for equipment	
HV (161 kV)	170 kV
LV (15.8 kV)	24 kV
Nominal system voltage	
HV (161 kV)	161 kV
LV (15.8 kV)	24 kV

[2] indicative value, the final value is up to the design of the supplier

Power frequency withstand voltage, 50 Hz 1min

HV (161 kV)	325 kV
LV (15.8 kV)	50 kV

Lighting impulse withstand voltage 1,2/50 µs

HV (161 kV)	750 kV
LV (15.8 kV)	125 kV

Even IEC-standards permit 10% tolerance for no load and load losses it is required that the maximum tolerance for no load and load losses is 5% of the declared losses.

2.4.4 Construction of unit transformers

Core

The transformer core shall be built with non-ageing cold-rolled grain oriented silicon steel laminations having a high permeability and low loss coefficient. Laminations shall be thoroughly covered with an inorganic coating such as Carlite or equivalent.

Cores shall be rigidly clamped in order to resist distortion caused by short circuit stresses or handling during transportation. Core bolts or nuts, if used, shall be insulated and tested by applying 2.5 kV - 50 Hz during 1 minute between bolt and ground or core.

Cores shall be securely earthed to the tank in an effective manner; the internal earth connection shall be of the detectable link type and shall be located in an accessible position.

All cores shall be constructed to enable a coherent magnetic flux and avoid any stray flux or undue local overheating, especially at exposed locations.

The core armour is to be constructed to withstand all mechanical stresses, which may occur during service, including those due to incorrect parallel operation or due to short circuit at full primary voltage.

Windings

The windings shall be of electrolytic copper, free from burrs and slivers.

Windings shall be designed to obtain an optimal value for series and shunt capacities to have a correct distribution of the voltage as well for full waves as for chopped waves. The Contractor shall state which measures have been taken to increase the resistance against these stresses. The insulation material shall be chosen such that they do not soften, shrink or degrade during the lifetime of the transformer.

The coils shall withstand short-circuits, overloads and high voltage stresses without local overheating. To ensure low short-circuit losses, the maximum current density inside the windings shall be below 2.5 A/mm². Leads from windings to terminal board and bushings shall be rigidly supported to prevent injury from vibration and short circuit forces.

The arrangement of tapings will be in such manner, that the magnetic symmetry of the windings is maintained to the maximum extent under all tapping conditions.

Power frequency withstand voltages of the neutrals shall be 65% of the respective line withstand voltages in accordance with IEC 60076.

Tanks and Fittings

The transformer tanks will be constructed in welded sheets of high quality carbon steel, reinforced in order to withstand the most severe conditions of operation, transport and vacuum treatment. The transformer tank construction shall be of the bolted cover type, however the welded bottom "bell" design, is also acceptable.

All the transformer tanks shall be absolutely water and hot oil tight and resistant to 100 % Vacuum.

The necessary gaskets will be tight under all conditions especially against the hot oils (synthetic rubber or neoprene bonded cork will be preferred). Means shall be provided to prevent over compression of the gaskets.

All tanks will be suitably braced to withstand, without distortion or buckling, the stress imposed during transport and operation.

The necessary lifting lugs and shackles shall be provided to enable the whole transformer to be lifted by crane.

The tanks shall be designed for easy removal of the bushings and easy connection to the windings. Suitable guides shall be provided within the tank to ensure correct positioning of active part.

The construction of the base shall permit the handling of the entire weight of the completely filled transformer. Pulling eyes shall be provided to allow the attachment of pulling rigs and moving the transformer horizontally on wheels or rollers in either direction.

Jacking pads shall be available at convenient locations on the transformer tanks to allow the jacking of the completely filled transformer.

Each transformer shall have two earth connections of adequate dimensions. These shall be located near the bottom of the tank at diagonally opposite sides.

For corrosion protection a multilayer corrosion protection of different thicknesses (2 base layers, outer layer 1) will be applied. The inside of the tank, the cover and the expansion vessel are coated with an oil-resistant paint.

Painting and corrosion protection shall be according to the GTS.

Cooling

The units shall be executed by ODWF or OFWF (Oil direct/forced water forced) cooling system.

The losses will be absorbed in the tank by the insulating oil and discharged with the oil flow to oil-water coolers and discharged to the cooling water. The cooling water for both unit transformers will be provided from a central cooling water system of the power plant. The max. cooling water inlet temperature is 30 ° C, minimum is expected by 7 °C.

The max. permissible temperature rises must not be exceeded when the cooling water temperature is at its maximum value.

The transformer must be able to release the residual heat in switched off condition in case of grid failure without exceeding the permitted temperature limits (given in the technical data).

The cooling equipment of each transformer shall be furnished complete in every respect and shall include pumps, piping, valves, motor contactors, relays, control equipment and all supplementary equipment required for the good function of the cooling system.

The transformer shall be provided with a sufficient number of cooling units, divided in groups for control purposes. Relay control (thermostatic) shall be provided to start, in steps, first one group then the second group of coolers or even both cooler groups simultaneously, when the transformer winding temperature increases beyond a predetermined value. A transfer switch shall be provided to permit manual selection of the one or the other cooler groups, which is to operate first. Moreover, an "automatic" - "manual" selector switch shall also be available to allow for switching on or off manually either of the cooling groups.

The cooling system sizing shall be based on continuous rated power transfer with one of the cooling units out of service. Even in this case the admitted temperature rises shall be within the admitted borders.

Each cooler unit or group shall be provided with valves on the tank side and be designed such, that it can be removed for service or be replaced, without disturbing major parts of the transformer and without the need of interruption of the transformer operation. Lifting lugs, drain- and vent plugs shall be provided for each cooler unit.

All necessary automatic controls, contactors, etc. for the cooling system of each transformer shall be installed in a control cabinet mounted on or near the transformer.

Motor leads for pumps shall be of weatherproof design or totally enclosed in a weatherproof flexible conduit.

On-load tap changer

Voltage regulation shall be performed by means of a three-phase on-load tap changer of the transition resistor type, to be inserted on a star point of the unit transformer. The on-load tap changer shall comply with IEC Publication 60214.

The diverter switch shall operate by means of quick-release stored energy mechanism and shall include an independent means of storing energy for its operation, actuated by both hand operation and motor drive mechanism.

Diverter switch and tap selector shall be mounted in the main tank of the transformer. The diverter switch, which breaks and makes currents and thus contaminates the oil, shall be located in a special container, in which the oil will be kept separated from the transformer oil. A removable bolted cover shall be provided for the access of to the diverter switch container without opening the main tank or lowering the oil in the main tank.

Taps for oil sampling, valves for oil conditioning and oil drainage system shall be provided for the diverter switch container.

The tap changer shall operate by means of a motor-driven mechanism fitted outside of the tank. Motor operation shall be started either by local or remote control.

A removable hand-crank shall also be provided for manual operation of the tap changer with blocking of the motor-drive taking place before actual engagement of the crank with the manual operating shaft.

Overcurrent protection for OLTC (to prevent operation during fault)

Bushings

The LV bushings will be connected to the generator by means of isolated phase bus ducts (IPB) to be furnished under other chapter of this specification. Bolts and nuts for these terminals shall be provided by the Contractor.

LV bushings for the secondary side and the neutral point shall be of solid type. The LV bushings shall be mounted on the opposite side of the HV connection.

The neutral terminals of the transformer shall be grounded at ground terminal of the transformer or connected directly to the powerhouse grounding mesh with either stranded copper conductor or copper bar. Cross section of these bars or conductors shall not be less than 120mm^2. Grounding current transformer to be installed for control and protection purposes.

The neutral grounding, formation of the star point and connection to ground shall be furnished by the Contractor.

On the HV side the transformer will be connected to the grid via one three phase 161kV XLPE cable system. Therefore suitable HV cable plug connection shall be installed.

The design features including type, insulation class, current rating shall conform to the specified standards. Design shall ensure that there will be no corona formation during operation and testing.

The HV cable socket shall be mounted on the tank cover and be suitable to standardized cable connector (e.g. type Pfisterer).

One additional cable socket system shall be provided for installing of pluggable surge arrestor type (e.g. type Pfisterer). The necessity of HV surge arresters at the unit transformers has to be proofed by the supplier with all appropriate calculations.

The XLPE cable system including the cable termination (plugs) and cable earthing accessories shall be part of cable system supplier.

Transformer oil system

All transformers supplied under this contract shall use the same make and type of oil.

Oil used in the filling of the transformer will be pure mineral oil, unmixed with any other substance, refined especially for use in transformer, free from moisture, acid, alkali and sulphur components. It shall be suitable for the ambient conditions prevailing at site.

The transformer will be delivered with the necessary oil for filling and additionally a 5% quantity of spare.

The transformer oil will comply with the corresponding IEC recommendations and standards.

The transformer shall be fitted with the required number of valves for filling, draining and oil treatment. Connections for filter and vacuum dryers shall be chosen to allow connection to the Owner’s purification plant. The valves shall be able to be sealed against transformer oil above 100°C.

A conservator vessel complete with sump and drain valve shall be provided for the transformer in such a position as not to obstruct the electrical connections to the transformer and shall have sufficient capacity to allow oil expansion from 10°C to 100°C. The conservator vessel shall be designed in such a way that it could be completely drained by means of the drain valve mounted when in service. A rod type oil level gauge showing the full oil level ranges shall be provided. Each conservator shall be filled with one breather of normal size filled with silica-gel as a dehydrating agent. The breather shall be provided with a separate isolating valve.

Protection devices

Pressure Relief Device or Explosion Vent

The transformer tank shall be fitted with a pressure relief device or explosion vent. It will be built on the cover to protect against high pressures inside the oil tank. It shall be provided with closed cover used as diaphragm which ruptures at a gauge pressure of 0.55 to 0.7 bar (preferably, the sealing of the explosion vent may be accomplished by a spring closed cover, having the same pressure gauge as before).

Buchholz Relays

The transformer shall be equipped with a Buchholz relay of earthquake proof design. These relays shall be mounted in the pipe connecting the conservator to the transformer tank.

The Buchholz relay shall be of the double float type with two sets of independent mercury contacts (one float actuated by a build-up of gas and the other by a sudden oil surge giving respectively signalization and tripping).

Adequate isolating valves shall permit the removal of the Buchholz relay, the conservator being still connected to the tank by a pipe shunting the relay.

The relay shall be provided with a window having a scale for reading the gas level. It must be possible to take at any time a gas sample from the device through a vent screw. It must also be possible to test the Buchholz relay when the transformer is in service.

Temperature Detectors and Temperature Indicators

The transformer shall be equipped with:

Resistance Temperature Detectors

Resistance temperature detectors of the Pt 100 type (100 ohms at 0°C according to DIN 43760) shall be installed in an appropriate and approved manner in the following places:

Two (2) in the hottest spots of the core for remote temperature indication

Two (2) at the location of the hottest oil for remote temperature indication, provided the Contractor would prefer to have this device combined with the temperature indicator as given in paragraph hereafter.

For each water cooling group.

These shall also include signal transformation for an output signal of 4 to 20 mA.

Temperature indicators

For measuring the temperature of hot oil locally, each transformer will be provided with a dial thermometer complete with two electrical alarm contacts. The mercury bulb will be placed in an oil-filled pocket screwed into the transformer cover. The thermometer housing will be of hose-proof, metal clad ventilated design. Contacts must be available for starting the pumps.

The indicating instrument shall be of stainless steel. The casing must be spring-suspended on the tank at eye-level. The dial will be scaled from -20°C to 150°C. A maximum pointer shall be provided which may be reset at any time by means of a push button.

The cooling water shall be indicated by dial thermometer.

Two or more additional pockets for the insertion of thermometers to check oil temperature shall be provided on the cover of the transformer.

Thermal image

The transformer shall be provided each with one thermal image. It will give the hottest spot temperature of the corresponding winding. The hottest spot temperature will be indicated on a dial thermometer placed on the tank (the scale of the dial thermometer will be at least up to 150°C).

Contacts will be available for alarm, tripping and for continuously starting the cooling pumps.

2.4.5 Transformer monitoring system

For permanent condition monitoring and early fault detection of the unit transformer an online monitoring system shall be provided.

It consists essentially of a gas-in-oil analysis-supervision (DGA) and collection of general operating data. The data shall be analyzed, trends shall be displayed, lifetime will be estimated.

- Foreign substances in the oil
- Temperatures, oil levels
- Voltage, current, power, losses on the transformer
- Operating condition of cooling
- Overload conditions

DGA analysis device shall provide information for estimated winding hot spot temperature, moisture level in paper and moisture bubbling temperature, insulation ageing, overloading capacity, cooling efficiency and OLTC temperature differential.

Following measurements shall be applied:

Gas Sensor: Fuel cell type sensor behind a gas permeable membrane in contact with mineral transformer insulating oil through a flooded manifold, measurement range 0-2000 ppm (volume/volume, H_2 equivalent), sufficient measurement accuracy and sensitivity for H_2, CO, C_2H_2, C_2H_4 concentration,

Moisture Sensor: thin film capacitive type sensor immersed in mineral insulting oil through a flooded manifold, measured range 0-100% RH with sufficient accuracy

Features:

Display with Keypad, digital communications for local and remote system, Gas and moisture level and trend data output, local alarm for gas and moisture, service in different configurations.

2.4.6 Control and Terminal Cabinets, Wiring

All necessary automatic control, motor starters, protective devices, switches etc. for cooling equipment of each transformer shall be assembled in a dust proof and weatherproof metal cabinet arranged for mounting on the respective transformer units.

This cabinet shall be accessible from ground level and be provided with a door for front access, handles locking facilities (key locks), heaters, internal lighting and electrical outlet on separate conduits.

All secondary wiring used on each transformer shall be carried out in suitably supported galvanised steel conduits or metal protective channel (bows and branches must be open) and brought to an adequately dimensioned terminal cabinet with sealed cover or equivalent design.

All power and control cabling or wiring shall terminate in terminal blocks located in the cabinets described above. Two rows of terminal blocks shall be available arranged opposite each other, one for the external cables and one for the transformer cables. The wiring and terminal blocks shall be neatly grouped and arranged to permit connection with minimum number of external cables.

The control and terminal cabinets may be combined in a suitably dimensioned common cabinet.

2.4.7 Transport

For transport purposes the dimensions within the main access tunnel and power cavern are limited. This requirement has to be considered in the overall design of the transformer dimension.

The transformer tank will be shipped filled with nitrogen gas or dry air. Means for indicating and maintaining the gas pressure inside the tank during transportation shall be provided. The transformer having the transport weight over the transportation limitations shall be shipped without oil.

The oil filling shall be performed at site. The putting into service of the transformer may be done without further drying out. (Transformer oil must be treated)

All openings for transformer components e.g. bushings which have been removed from the transformer during transport shall be covered by means of blanking-off plates and spare gates, specially provided for this purpose.

2.4.8 Inspections and Tests

Factory Tests

The transformer and its related equipment shall be subjected to acceptance tests, to be performed at the suppliers' workshop in order to prove conformity with the guaranteed and other key design data. These tests shall include as a minimum the following measurements, evaluations and all tests required by IEC 60076-1 to 3, 60137 and 60214:

1. Measurement of ohmic resistances
2. Measurement of zero sequence reactance
3. Measurement of winding capacitances
4. Measurement of voltage ratio in all steps and check on polarity and vector group.
5. Measurement of no-load current and losses
6. Measurement of impedance voltage and short-circuit losses
7. Determination of efficiencies
8. Induced and separate source high voltage withstand tests
9. Full wave impulse voltage withstand test
10. Partial discharge test
11. Heat run test (applied at one transformer of each type only)
12. Noise level measurements (this test may be waived, if type test certificates of similar transformers can be submitted).
13. Determination of errors and accuracy of built-in current transformers (test sheets to be provided)
14. Functional test of all electrical control and supervisory equipment
15. Visual inspection
16. Test of tap changer according to relevant IEC standard

Field tests

After final installation at site the transformer shall undergo a test program according to the manufacturer's practice, (test program is subject to the approval of the Owner.)

At least the following test shall be performed and included in the offer:

1. Visual check for transportation defects and tightness
2. Visual check of the erection according owner approved drawings

3. Insulation measurement of the electrical installations
4. Function test of protection and monitoring systems
5. Function test of cooling system, valves, gauges

The transformer oil shall be tested from an independent testing organization during erection, 1 year after hand-over of the equipment through the Owner and 1 month before end of the guarantee time.

One compressed air cylinder with rubber hose and pressure gauge for testing the Buchholz relays shall be delivered.

2.4.9 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

2.5 Station Service Transformers

2.5.1 Design particulars

These transformers shall be able to operate continuously at rated power output without exceeding the stated temperature limits at any tapping and any feeding voltage within the above stated range. Exceptionally the feeding side can also be the LV-side, voltage variations being similar. It shall be compact and easy to install.

It shall be subjected to load rejection conditions (to coordinate with motor-generator data).

Unbalanced loading on the LV side shall be permitted up to 25% of the rated current on one phase continuously and up to 100% for short duration (3 minutes).

The design has to be short circuit and impulse voltage persistent, as well as E2 class.

The windings shall not absorb any humidity.

2.5.2 Technical data

General

Type	three-phase cast resin dry type
Location	indoor
Number of phases	3
Rated frequency	50 Hz
Rated voltages on main tapping (LV)	0.4 kV
Insulation class (utilization)	F (B)

Three phase vector diagram	Dyn5
Neutral grounding	solidly grounded
Cooling system	AN
Max. average sound level (at 2 m)	< 60 dB (A)
Protection class	IP00

15.8 kV SSTr 1, 2 in the powerhouse

Rated voltages on main tapping (MV)	15.8 kV
Short-circuit impedance (medium tap)	6 %
Rated power	1600 kVA
Tapings on MV side	± 2 x 2.5 %, off load
Number of units	2

22 kV SSTr 3, 4 in the powerhouse

Rated voltages on main tapping (MV)	22 kV
Short-circuit impedance (medium tap)	6 %
Rated power	1600 kVA
Tapings on MV side	± 2 x 2.5 %, off load
Number of units	2

22 kV SSTr in the upper reservoir operating building

Rated voltages on main tapping (MV)	22 kV
Short-circuit impedance (medium tap)	4 %
Rated power	160 kVA
Tapings on MV side	± 2 x 2.5 %, off load
Number of units	1

0,69 kV or 0.95 kV Step up/down transformers operating building and lower reservoir bottom outlet

Rated voltages on main tapping (LV)	690 V or 950 V[1)]
Short-circuit impedance (medium tap)	4 %
Rated power	100 kVA

Tapings on higher voltage side ± 2 x 2.5 %, off load

Number of units 2

Including encloser (cubicle) for transformers.

1) The voltage level 690 V or 950 V will be decided during detail design.

2.5.3 Temperature Detectors and Temperature Indicators

Default parameterized PTC sensors will be placed at the hottest spots on the low voltage winding. The sensors shall protect both high voltage winding and low voltage winding. An appropriate temperature indicator has to be installed.

2.5.4 Connections

The connections to the corresponding MV switchgears and LV switchgear in the upper reservoir operation building, operating building, lower reservoir bottom outlet will be made by means of cables. For the connections to the 400 VAC main distribution switchgear in the powerhouse, busbar connections shall be installed.

2.5.5 Inspections and Tests

The routine tests are defined in the General Technical Specifications.

2.6 Documentation

2.6.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

2.6.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3

Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Calculations (including short circuit calculation) and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 months before commissioning

2.7 Optional design requirements

The system supplier shall review, check and prepare a separate price item for the proposal for below defined optional design.

In best case the current room dimensions can be kept. In case the transformer box will not be of sufficient size the additional space shall be mentioned in the proposal and shall be as small as possible.

The scope of supply shall include all kinds of support structures and accessories.

2.7.1 Unit transformer – 161 kV Earthing and disconnector combination

To have an additional earthing location at the unit transformer within the power house the supplier is requested to provide an economical design for a earthing and disconnector switch combination on the 161 kV high voltage side in the transformer cavern. With the current design the cable system and unit transformer will be earthed by remote earthing switch of the high voltage switchyard.

Following known alternative technical solution could be executed.

- The earthing and disconnector switch can be designed as air insulated arrangement mounted on the inner wall of the transformer cavern. Instead of the pluggable cable terminals dry or flexible outdoor terminations (e.g. Pfisterer) shall be used, which can be mounted headlong to the ground or horizontally. The 161 kV cable plugs have to be changed to transformer bushings. The electrical short connection shall be done by Aluminum ropes or bus bar.

- The earthing and disconnector switch can be designed by a gas-isolated transformer connection unit including the pluggable cable terminations.

- Other suppliers solution

2.7.2 Unit transformer – Fire protection system

The main transformer shall be protected by an inert gas injection system which is in line with international standards.

The required system shall be a transformer explosion and fire prevention system suitable for of oil-immersed transformer including on load tap changer.

During a short circuit, the protection system will be activated within milliseconds by the first dynamic pressure peak of the shock wave, avoiding transformer explosion before static pressure increases. When activated the explosive oil and gases are routed to the separator tank which are then separated. The explosive gases are routed to a remote area where they are evacuated without causing possible damage to the plant equipment.

The transformer and on-load tap changer depressurization sets shall allow the depressurization in case of an internal fault. The depressurized oil and gas mixture is routed to an oil-gas separation tank. The gases are expelled through the explosive gas evacuation pipe, to a remote area where gases can burn safely. An air isolation shutter is installed at the end of the explosive gas evacuation pipe to avoid air from entering into the oil-gas separation tank or the transformer tank.

The Contractor shall submit detailed technical operation manual of the system together with reference list, ISO 9001 certificate, commissioning and maintenance instructions as well as general layout drawings for the main components.

3 STATIC FREQUENCY CONVERTER PLANT

3.1 General Description

The start of the motor-generator in pump operation is normally done by means of the static frequency converter (SFC), which will be connected on the motor-generator switchgear over corresponding switching devices.

The SFC will be supplied by a feeder of the 15.8 kV switchgear. The out let side of the SFC will be connected to the starting switch which is integrated in the generator circuit breaker. The SFC accelerates the excited motor-generator up to the grid synchronisation. The grid connection will be made via the generator circuit breaker.

Explanations of terms

- SFC plant means the overall system including the converter, the transformers (if necessary) and the outlet switchgear, SFC control system, cooling system, etc. and all interconnections
- SFC means the electronic converter which are containing the rectifier, the dc-link and the inverter

3.2 Scope of Supply

This specification covers the design, manufacture, testing at the factory, transportation from factory to site, storage, complete erection, testing and commissioning of one static frequency converter plant, including all the necessary accessories and tools required for the installation, operation and maintenance of the plant. Necessary design works to get a correct communication to other equipment, as well as the definition of interfaces to other suppliers must be part of the supply. The SFC plant shall include (but not limited to) the following equipment and materials, whereas a solution without transformers is permitted if this doesn´t result in any restrictions:

- Transformers (if necessary)
- Converter
- Cooling System
- Outgoing switchgear
- All interconnections within the SFC plant
- All facilities for the implementation of the SFC plant in the overall control and protection system

The SFC plant shall be appropriate in all respects for the associated packages of work, such as the motor-generators supplied under part 2 of this contract and the generator-motor isolated phase bus ducts, and shall comply with the requirements of the national grid code at all times. Any contrary statements in this document shall not limit this requirement.

3.3 Interfaces

The specification is outlined as functional description and therefore does not contain any technical detail design. Internal interfaces of the main components and to other parts of the Contract are summarized in the Volume 2 / Section XI.

3.4 Standards

Israeli standards, where applicable and available, shall be used. Unless otherwise specified the equipment shall be designed in accordance with the latest edition and amendments of the appropriate IEC recommendations, in the event that there are no applicable IEC specifications, the DIN or VDI Standards shall be adopted.

The following standards shall be applicable in particular.

IEC 60204	Safety of machinery – Electrical equipment of machines
IEC 60076	Power Transformers
IEC 60276	Dry type Power Transformers
IEC 61869	Instrument transformers
IEC 60909-0	Short circuit currents in three phase A.C: system
IEC 60146	Semiconductors Converters
IEC 60289	Reactors
IEC 60298	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV an up to and including 72 kV
IEC 61131	Programmable Controllers (All Parts)
IEC 61800	Adjustable speed electric power drives
IEC 61850	Communication networks and systems in substations
EN 50178	Electronic equipment for use in power installations
IEC61000	Electromagnetic Compatibility (EMC)
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEC 61378	Converter transformers–Part 1. Transformers for industrial applications

3.5 SFC Losses

No-load losses shall be defined as the total input power to the SFC equipment with input and output transformers energized and input and output circuit breakers closed, all auxiliary equipment on-line, and no converter power flow. No-Load Loss include the excitation currents drawn by the input and output transformers.

Load losses shall be the difference of total losses and the no-load losses. Total losses shall be the difference of total input power and the total output power from the SFC equipment with the input and output systems connected to the SFC equipment (input and output transformer breakers closed), all auxiliary equipment on-line, and full rated power flow through the SFC equipment at nominal input and output voltage.

3.6 Guarantees and Rejections

All guarantee values are defined in the document Volume I - Schedule III Particular Conditions of Contract - Annex 11.

This section describes the specific guaranteed values for the SFC plant. All the guaranteed data must be filled into the corresponding datasheet.

- The rise of the temperatures of the step up and step down transformers exceeds the permitted limits for the described load cycle (section 3.7.3.1)

Moreover the Contractor has to guarantee compliance with all technical data given in the corresponding datasheets.

3.7 Static Frequency Converter

3.7.1 General Description

The converter consists mainly of a controllable rectifier, a DC intermediate reactor and an inverter.

The DC intermediate circuit with reactor forms a controllable DC power source. The inverter switches the DC and generates a three-phase AC voltage with variable frequency and voltage.

3.7.2 Scope of Supply

- twelve - pulse fully-controlled rectifier bridge (line converter), (six pulse is also permitted if grid code can be fulfilled)
- dc link reactor,
- six- pulse fully-controlled inverter bridge (generator side converter),
- series and/or parallel-connected filtering plant to limit the adverse effects of the SFC operation on the power quality of the power station's electrical

systems; the Contractor has to prove if the filters are not necessary with a correspondent calculation

- Transient over-voltage suppression system
- connection to the grounding system of the cavern
- all control, monitoring, instrumentation and protection equipment, including synchronising facilities, cubicles, enclosures, cages, etc., as appropriate,
- measuring, testing and safety equipment,
- all associated accessories, including but not limited to:
    - anchors, embedments and any other mounting equipment required for the assembly, mounting and dismantling of all elements of the equipment,
    - lifting eyes, bolts and fixtures as required to conveniently handle any part or any assembly of such parts for initial and future assembly and disassembly,
    - all power, control and instrumentation cabling within the SFC plant, all the electrical auxiliaries, up to the cubicles mentioned above.
- special tools,
- and other items required for completeness.

3.7.3 Design Particulars

The technical conditions according to the General Technical Specifications applies.

3.7.3.1 General Operating Conditions

The primary method of starting the units in the pumping mode will be by SFC plant. The pump-turbine runner chamber will be dewatered prior to start sequence initiation, for operation in both starting modes.

The SFC plant shall be supplied with input power at motor-generator rated voltage from connections to the 15.8 kV switchgear.

Motor-generator starting shall be possible throughout the specified supply voltage and frequency range.

The SFC plant shall be capable of starting the motor-generator unit from zero to synchronous speed in the pumping direction in a time which enables full power pump operation within 340s (as given by IECo). This requirement shall be fulfilled even in case of one faulty switching element.

Load cycle
For the design of the SFC plant the following load cycle shall be applied:
1. Braking of unit from turbine operation
2. Start-up of unit in pump mode and interrupting the procedure before synchronizing
3. Start-up of unit in pump mode with synchronisation
4. Braking of unit from pump operation

For each of these load cycles the SFC plant will be operated at full load. Within this load cycle no break or shut down is allowed.

Operating mode

The PSPP Manara will be operated with frequently load changes and change overs between turbine and pump operation mode. Several start / stop cycles a day will occur (as defined in the General Technical Specifications).

For the SFC plant the following continuously operation mode shall be applied:

SFC is in stand by:

1. Load cycle according to the description above
2. 25 min break

Load cycle to be repeated indefinitely.

A reduction of the brake-time is sought and will be rated in the tender evaluation phase. The information according to the above load cycle shall be given in the datasheets.

3.7.3.2 Performance requirements

For commissioning purposes the units could be required to run for extended periods at part speed for balancing and alignment adjustments whilst driven by the SFC plant. The SFC plant shall include means of controlling the motor at constant reduced speeds. Any limitations in operating times at speeds below rated speed shall be stated in the data sheet.

The SFC shall have a frequency follow-up function to allow it to follow the system frequency smoothly during synchronizing of the machine. The frequency follow-up function shall be able to be switched off manually.

At the connection point to the starting switch the short circuit power has to be restricted via reactors.

Components shall be rated to ensure high availability and reliability of starting with minimum maintenance, with a design that supports quick replacement of major and minor components with a minimum of downtime.

The rectifier and inverter switching elements banks shall have N+1 redundancy and each shall have excess forward current capability to meet this requirement. The redundancy concept shall be explained with the bid.

The SFC plant shall have regenerative braking functionality to stop a running motor-generator by reversing the functions of the rectifier and inverter.

The SFC shall operate reliably and shall not impose restrictions on the availability of the units due to converter plant faults or malfunctions.

3.7.3.3 Responsibilities for Control and Auxiliary Equipment

The Contractor shall be fully responsible for all necessary equipment for the control, indication, protection and alarm of the SFC plant.

The Contractor shall be responsible for the provision of the control and auxiliary equipment and for co-ordination with the other Contractors and manufacturers for proper operation of the SFC plant.

3.7.3.4 Harmonic Distortion

Without installing filters the SFC plant shall produce minimum harmonic distortion into the high voltage and medium voltage power system when in pumping or regenerative braking mode, so that the other units and station plant operation is unaffected. It shall comply with national IECo regulations, IEC61000 respectively IEEE 519, whichever is the more onerous.

The Contractor shall undertake a harmonic study on the predicted harmonic levels that will be generated into the HV and local powerhouse MV networks. This shall verify that the harmonic levels do not exceed those specified mentioned regulations.

3.7.4 Technical Data

Frequency range	0 – 53 Hz controllable
Output voltage	0 – 15.8 kV ±6% controllable
Rated symmetrical short circuit	25 kA for the 15.8 kV switchgear
Start up in pump operation mode	max. 340 s to full load pump mode (according to IECo requirements)

3.7.5 Electronic power converters

Fully controlled three-phase bridge converter shall be provided. The design shall allow easy replacement of semiconductor devices and also fuses if used. Only explosion-proof semiconductor devices are allowed to be installed. For each of the series connected controlled rectifiers in each branch, a self-triggering over-voltage protection circuit shall be provided.

The SFC has to be designed for the entire voltage range. A solution with no tap changers is preferred.

Alarm and trip facilities shall be provided to cover failures of the cooling system. The design shall take account of the water supply pressures as stated in the Data Sheets if the station common services cooling water system is utilised.

3.7.6 DC-reactor

Smoothing reactors shall be provided in the intermediate DC circuit in order to reduce the DC current pulsation and to make the inverter operate stably and reliably.

The smoothing reactor shall be dry type, single phase, aluminium coil, with an iron core.

Windings for the reactor shall be provided with class H insulation.

3.7.7 Control, Protection and Measuring Equipment

The SFC shall be designed with all necessary PLC based control, monitoring and protection equipment to enable operation from the control rooms. The static frequency converter shall operate as a part of the motor-generator control system.

The HMI shall be mounted on the front of the SFC panel. Indications of mode selection (local, remote, test, manual and automatic) shall be transmitted to the respective unit control system and SCADA.

The test mode will permit the operator to manually accomplish step-by-step starting of the unit in pumping mode and in synchronous condenser mode in the pumping direction from the SFC control cabinet. Test mode shall only be possible when the SFC is operated locally.

In manual mode, the SFCs shall be provided with controls to permit manual speed regulation of the unit over a range of adjustment between 5%-105% of rated unit speed. Manual mode shall only be possible when the SFC is operated locally.

In auto mode, the SFCs shall be controlled by the unit PLC. The SFC shall be able to execute automatically the whole starting sequence and return to a state of preparation for next starting sequence.

The SFC has to have a position detection of the rotor pole-position in relation to the stator in order to optimize the breakaway torque. This must be done by a flux density calculation due to an excitation current step response.The rotor pole-position detection shall be realized without additional sensors.

Necessary measuring devices at the excitation resp. at the generator switchgear has to be defined in the technical tender documents.

Disturbance recorders shall be provided. Triggering of each recorder shall occur either manually (including via plant SCADA), or by the action of any protective relay or converter control system fault detector.

The technical requirements for the control-, protection- and measuring devices has to be defined in accordance with the Owner.

The entire protection equipment of the SFC plant, at any operation mode and at any faults (alarm or tripping) of the SFC plant or the motor-generator, has to be incorporated in the control and protection system of the plant, that a safe and orderly shutdown of the equipment takes place.

As the minimum, the following protection devices shall be provided:

- AC power supply side:
  - Over-current protection;
  - Over-voltage protection;
  - Under-voltage protection.
- Rectifier and inverter:
  - Differential protection;
  - Phase over- current protection;
  - Over- voltage protection;
  - Unbalanced current protection;
  - Pulse failure protection;
  - Ground fault protection;
  - Circulating current protection (if multiple converter connections are used);
  - Over temperature protection.
- Other protections:
  - Excessive unit starting time;
  - Unit over-speed protection;
  - DC circuit earth fault protection;
  - Cooling system failure;

All faults and alarms shall be displayed on SFC HMI. Alarms shall include, but not be limited to, the following:

- Overload at AC side;
- Over-current at DC side;
- Cooling failures;
- Controlled rectifier fault;
- Control power supply fault; and
- Others.

Input and output values of currents and voltages shall be shown on the local HMI. All parameters critical for safe operation of the SFC shall be displayed on the HMI and shall include, but not limited to, the following:

- Phase voltages;
- Phase current;
- Frequency;
- Harmonics;
- Active power;
- Reactive power;
- Unit speed;
- SFC DC current; and
- Others as necessary.

The Contractor shall provide electric shaft angle-measuring, speed-measuring, or voltage measuring devices as necessary for operating of the SFC. Selection of the method and hardware to perform this function shall be made by the Contractor in accordance with their manufacturing practice. Devices mounted on the main shaft of the unit shall be capable of operating in high intensity electromagnetic fields and intense vibration conditions. Devices mounted on the shaft shall be complete with dust proof covers.

In principle, all warnings and alarms are to be connected to the overall control system via LAN connection. On the display directly on the SFC all warnings and messages will be shown. This applies also to the alarms and warnings of transformers and the outgoing switchgear.

Safety relevant messages must be wired to the corresponding terminal block.

3.7.8 Surge protection

The AC side of rectifier and inverter shall be facilitated with protection device absorbing the surge over-voltage;

The surge over-voltage device shall be selected to ensure protection of the controlled rectifier elements against damages by transient over-voltages;

The protection devices absorbing the surge over-voltage shall be mounted in an enclosed cubicle;

The components of the transient overvoltage device (such as the arrester and capacitor) shall conform to the corresponding requirements of IEC standards;

One set of protection devices against transient over voltages shall be provided on the AC side of the SFC rectifier bridge and the inverter bridge of the SFC. Protection shall consist of single-phase, gapless arresters shunted with capacitors, or other effective methods.

3.7.9 Cooling System

The SFC including the DC reactor is provided with a pure water cooling plant. The power converter losses and the losses of the DC reactor shall be transferred to the cooling water of the Power Plant (closed cooling circuit) via a heat exchanger.

All respectively control devices shall enable a start-up or braking procedure at any time.

The redundant pure water cooling circuit consist mainly of the heat exchanger and the circulation pumps. The circulation pumps has to be supplied redundant. In case of failure an automatic switch over has to performed without interruption.

The pure water circuit must be designed so that a pump start or braking of the unit can be done without cooling water of power plant. Also in case of failure of the cooling water supply of the power plant during a braking or a pump start, it may not come to a termination due to lack of cooling water supply.

The pure water circuit as well as the external cooling water circuit located in the SFC has to be monitored for temperature, flow and pressure. The external cooling water circuit has to be executed in stainless steel and with flange (pressure rating PN 10). Corresponding vents for the filling must be provided.

The following transducers shall be provided:

- Inlet and outlet raw cooling water flow, pressure and temperature;
- Inlet and outlet demineralized water flow, pressure and temperature
- Conductivity probes.

Other instrumentation:

- Manual off auto pump control switches;
- Auto changeover control for pumps;
- Loss of power alarm (control and power;
- Pump overload alarm.

3.7.10 Optional Design

The system supplier shall review, check and prepare a separate price item for the proposal for below defined optional design.

Forced air cooling might be foreseen for the SFC instead of water cooling. With redundant fans and correspondent temperature supervision.

3.7.11 Future Replacement of SFC System

The Owner expects that the SFC plant is likely to require complete replacement at least once during the life of the power station owing to component obsolescence. The design of the SFC plant should consider ease of maintenance and fast-tracked wholesale replacement of components of the SFC system to be important features.

The design shall allow minimum downtimes when routinely replacing failed components and when upgrading or uprating large sections of the SFC plant.

The Contractor must ensure the proper communication - for all operating cases - between the SFC plant and the power plant control system, the excitation system the motor-generators, etc.

3.7.12 Documentation

3.7.12.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

3.7.12.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Transport way of equipment	Design Drawing	3
Single line diagram	Design Drawing	3
Arrangement drawing and layout	Design Drawing	3
Block outs for Cable Routing	Design Drawing	3
Foundation drawings	Design Drawing	3
Installation diagram	Design Drawing	3
Inspection and test plan	Technical Description	5
Requirements for the 15.8 kV switchgear	Technical Description	5
Requirements to the grounding system	Technical Description	3

Calculation of starting and braking time of the unit	Technical Description	10
Calculation short circuit	Technical Description	10
Operation_and_Maintenace_Manual	Technical Description	26

3.7.13 Inspections and Tests

3.7.13.1 Factory tests

- Insulation and voltage test (including power cable, panels, auxiliary equipment)
- Test of the control and protection systems
- Pressure (1.5 times of design pressure for 30 minutes) and tightness test of the pure water cooling system
- Test of the SFC components (alarm circuits, power electronic, DC reactor, etc.)
- Transformer type tests:
    - Lightning impulse test
    - Temperature rise test
    - zero-sequence impedance measurement
- Heat run with rated current (in short circuit mode)
- etc.

3.7.13.2 Site tests

- Insulation resistance measurement;
- Dielectric strength test;
- Function tests including performance test of control unit, adjusting unit, protection unit, local and remote operation, test of test/manual and auto modes;
- Operating simulation test for control, protection and measuring circuit;
- Silicon valve component test;
- Triggering facility performance test;

- Cooling system test;
- Noise level test;
- Simulation test for the unit pumping start sequence test;
- Auto and manual tests - start test, speed adjusting test;
- Temperature rise test; and
- Determination of no-load losses and load losses. No-load losses shall be carried out for a period of at least two hours and load losses shall be measured during a starting sequence.
- Transformers:
  - Insulation resistance measurement
  - Dielectric loss angle measurement
  - Voltage ration measurement
  - Impedance voltage
  - Excitation current

3.8 SFC-Transformers (if necessary)

3.8.1 General Description

The object of the SFC transformers is to adjust the grid voltage to the converter voltage on the line side and the converter voltage to the requirements of the start-up procedure of the unit.

The line side and motor-generator side decoupling transformers will be located next to the converter cubicles.

3.8.2 Scope of Supply

- one (1) three-winding line side decoupling transformer to supply the rectifier bridge
- one (1) motor-generator side decoupling transformer to suit the output requirements of the bridge and starting busbar system,
- connection to the grounding system of the cavern
- all control, monitoring, instrumentation and protection equipment,
- measuring, testing and safety equipment,
- all associated accessories, including but not limited to:

- anchors, embedment’s and any other mounting equipment required for the assembly, mounting and dismantling of all elements of the equipment,
- lifting eyes, bolts and fixtures as required to conveniently handle any part or any assembly of such parts for initial and future assembly and disassembly,
- all power, control and instrumentation cabling

- and other items required for completeness.

3.8.3 Design Particulars

Transformers shall be high flashpoint dry type air cooled. Transformers shall be supplied complete with terminal box, and all necessary auxiliary equipment and fittings.

These transformers shall be able to operate continuously at rated power output without exceeding the stated temperature limits.

The terminal arrangements and particular form of connections shall not restrict normal access around the transformer for maintenance and inspection purposes. All links for grounding and other purposes shall be readily accessible and the links and their fixings shall be of the captive type.

Transformers shall have the maximum possible levels of reliability and availability in service.

The design has to be short circuit and impulse voltage persistent, as well as E2 class.

3.8.4 Technical data

Type -	cast resin dry type[3]
	converter transformer
Location -	indoor
Number of phases -	3
Rated voltage HV side	15.8 kV ± 6%
Rated insulation level	24 kV
Rated LV side	acc. to Contractor requirements
Rated frequency	50 Hz
Short circuit ratio	acc. to Contractor requirements

[3] An oil immersed transformer may be offered as an alternative with a comparison of technical and economical advantages/disadvantages to the above described type.

Insulation class -	F acc. to IEC
Three phase vector diagram	acc. to Contractor requirements
Cooling medium -	Air
Cooling system -	AN
Max. temperature rise of the winding	80 K (by resistance)
Max. average soundlevel at 2m dB(A)	< 80
Protection class -	IP00
Frequency range	5 – 53 Hz for the generator side transformer
Type of connection	cable connections

3.8.5 Core

The transformer cores shall be built with non-ageing cold-rolled grain oriented silicon steel laminations having a high permeability and low loss coefficient. Laminations shall be thoroughly covered with an inorganic coating such as Carlite or equivalent.

Cores shall be rigidly clamped to resist distortion caused by short circuit stresses or handling during transportation. Core bolts or nuts, if used, shall be insulated and tested by applying 2.5 kV - 50 Hz during 1 minute between bolt and ground or core.

Cores shall be securely earthed in an effective manner; the internal earth connection shall be of the detectable link type and shall be located in an accessible position.

All cores shall be constructed to avoid any undue local overheating.

The core armour will be constructed to withstand all mechanical stresses, which may occur during service, including those due to incorrect parallel operation or due to short circuit at full primary voltage.

The holding frame must have lifting eyelets for lifting the whole transformer block.

3.8.6 Windings

The windings for the high voltage coil shall be of high grade electrolytic copper or aluminium, free from burrs and slivers. Enamelled wires or glass fibre isolated wires are permissible. For isolating and reinforcement only glass fibre and cast resin are allowed.

The winding for the low voltage coil shall be of high grade copper or aluminium free from burrs and slivers. The insulation class shall be F. The low voltage winding will not be laid directly on the core to achieve a cooling channel to minimise temperature rise.

The coils shall withstand short-circuits, overloads and high voltage stresses and mechanical distortion without local overheating. Leads from windings to terminal board and bushings shall be rigidly supported to prevent injury from vibration and short circuit forces.

The arrangement of tapings will be in such a manner that the magnetic symmetry of the windings is maintained to the maximum extent.

The line side transformer windings shall be shielded to reduce the transferred radio interference from the converter to the HV-Grid as well as protect the converter from transient over-voltages coming from the HV-Grid.

3.8.7 Transformer Cooling System and Requirements

All transformers shall be of the AN type of cooling. If necessary it shall be possible to retrofit the transformer with cooling fans. The forced air cooling shall be regulated automatically by sensors placed in the low voltage winding´s air ducts.

To minimize the heat dissipation, the losses of the transformer shall be as low as possible, both during load and no-load operations. Therefore the transformer type with the lowest losses available shall be chosen.

3.8.8 Grounding

The transformers shall be earthed to the main station earth bar at two points. All auxiliary equipment attached to the transformer shall be bonded to the tank. All other equipment such as separately mounted coolers, terminal box, shall be earthed to the main station earth bar.

Internal metal parts of the transformer, with the exception of individual laminations and clamping plates, shall be maintained at fixed potential.

The magnetic circuit shall be earthed to the clamping structure at one point only through an accessible link. The link shall be contained in a labelled lockable box mounted on the side of the tank or enclosure to enable the insulation resistance between the core and clamping plates to be measured for test purposes.

3.8.9 Temperature Detectors and Temperature Indicators

Default parameterized Pt 100 sensors will be placed at the hottest spots on the low voltage winding. The sensors shall protect the high voltage winding and the low voltage winding. An appropriate temperature indicator has to be installed.

3.8.10 Connections

The short-circuit proof connections to the corresponding MV and LV switchgears will be made either by means of cables or with bus bars.

3.8.11 Accessories

The transformers shall be equipped with the following accessories:

- Carriage
- Lifting eyelets
- Pulling eyelets
- Grounding connection

3.8.12 Documentation

3.8.12.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

3.8.12.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Transport way of equipment	Design Drawing	3
Arrangement drawing and layout	Design Drawing	3
Foundation drawings	Design Drawing	3
Installation diagram	Design Drawing	3
Inspection and test plan	Technical Description	5
Operation and Maintenance Manual	Technical Description	2 months before commissioning

3.8.13 Inspections and Tests

3.8.13.1 Factory tests

Each excitation transformer shall be subjected to a full series of routine and power frequency dielectric tests in accordance with the provisions of IEC Publication for Power Transformers and for Converter Transformers.

One converter transformer shall also be subjected to type test comprising:

- Heat run (temperature rise) test
- Audible sound test
- Check of temperature monitoring equipment
- Frequency Response Analysis

3.8.13.2 Site tests

Tests and inspections during commissioning according to approved inspection and test plan (ITP).

3.9 Switchgear

3.9.1 General Description

The switchgear system shall bypass the machine side transformer during start up period of pump operation as well as provide isolation and grounding of the SFC and transformer plant for maintenance. The general design features of the switchgear is described in the General Technical Requirements Specification.

3.9.2 Scope of Supply

- outgoing switchgear with short circuit reactors for by-pass operation, off-load switching, isolation and grounding of the SFC plant,
- connection to the grounding system of the cavern
- all control, monitoring, instrumentation and protection equipment, including synchronising facilities, cubicles, enclosures, cages, etc., as appropriate,
- measuring, testing and safety equipment,
- all associated accessories, including but not limited to:
  - anchors, embedments and any other mounting equipment required for the assembly, mounting and dismantling of all elements of the equipment,

  - lifting eyes, bolts and fixtures as required to conveniently handle any part or any assembly of such parts for initial and future assembly and disassembly,

  - all power, control and instrumentation cabling within the SFC plant, all the electrical auxiliaries, up to the cubicles mentioned above.

- special tools,

- and other items required for completeness.

3.9.3 15.8 kV Input Circuit breaker

The incoming circuit breaker for the SFC plant will be in the scope of the 15.8 kV switchgear. The SFC will control this circuit breaker. Also the protection and supervision will also act on this circuit breaker.

The concept of operation of the circuit breaker shall insure a maximum on availability and a minimum on maintenance costs.

3.9.4 Outgoing switchgear

The power output switchgear shall be designed for the variable frequency current and voltage occurring during pump starting and regenerative braking operations. The suitability of design for the particular operating role and electrical environment that this switchgear will perform in shall be supported by appropriate type tests.

The SFC takes over the control, all interlocks and all protection and monitoring devices of the outgoing switchgear.

3.9.5 Grounding switches and disconnectors

In SFC plant itself are disconnecting and grounding switches (depending on the design of the contractor). For these switching devices following specifications applies:

- it must be impossible to stop the switches after command electrically

- the switches have to be motor operated and operate with 220 VDC

- local control of the switches have to be possible

- an indicator shall show the position of the switches

- the switches must be lockable

3.9.6 Documentation

3.9.6.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

3.9.6.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Transport way of equipment	Design Drawing	3
Single line diagram	Design Drawing	3
Arrangement drawing and layout	Design Drawing	3
Foundation drawings	Design Drawing	3
Installation diagram	Design Drawing	3
Inspection and test plan	Technical Description	5
Interlocking scheme	Design Drawing	10
Signal list, logic diagrams, terminal diagrams	Design Drawing	10
Complete wiring diagrams of all cubicles	Design Drawing	12
Final schematic drawings of all auxiliary equipment	Design Drawing	12
Operation_and_Maintenace_Manual	Technical Description	2 months before trial run

3.9.7 Inspections and Tests

The inspections and tests are specified in the General Technical Specifications.

3.10 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

4 MOTOR-GENERATOR SWITCHGEAR

4.1 General Description

The connection between the generator and step up transformer will be made via metal enclosed isolated phase bus ducts with integrated instrument transformers and all necessary switching and grounding devices.

4.2 Scope of Supply

One (1) set of three-phase metal enclosed phase bus ducts (IPB) designed for 15.8 kV rated voltage and a nominal current of 9,500 A at Un between the generator and unit transformer including:

- Braking switch
- Generator circuit breaker including
  - Disconnector switch to SFC start up
- Phase reversal switch
- Current limiting reactors
- All necessary voltage and current transformers
- Grounding switches and lugs
- Surge arrestors, capacitors etc.
- as well as the tap-off connections to the excitation transformer, to the current limiting reactors and to the braking disconnector.

Cubicles for the generator for the line (phase) terminals and the neutral terminals, including any IPB needed for building the generator neutral point and all other components required for the generator neutral point, which are accommodated inside the cubicles.

One (1) set of monitoring, protection, control and other system equipment (e.g. pressurizing) all as needed for each IPB runs.

4.3 Standards

IEC 61869-2:2012	Instrument transformers
IEC 60060	High-voltage test techniques
IEC 60071	Insulation co-ordination
IEC 60105	Recommendation for commercial-purity aluminum bus bar material

IEC 60152	Identification by hour numbers of the phase conductors of 3-phase electric systems
IEC 60216	Electrical insulating materials - Properties of thermal endurance
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with rated voltages greater than 1000 V
IEC 60947	Low-voltage switchgear and control gear all applicable parts
IEC 62271	High-voltage switchgear and control gear all applicable parts
IEEE 1248	Guide for commissioning of electrical system in hydroelectric power plant
IEEE C37.013	Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis

4.4 Design particulars

Regarding the design of the generator switchgear special attention shall be paid and in respect of the high performance and availability requirements, to keep the operation and maintenance works as low as possible.

The whole bus bars and links shall be designed and built to safely withstand the thermal and dynamic stresses under normal operation and under all fault current conditions. Provisions shall be made for free expansion of conductor and enclosures due to thermal stresses by means of expansion pieces. Vibration occurring at the generator, transformer or circuit breaker shall not be transmitted to the bus bar systems.

The conductors of the bus ducts shall consist of bars with high breaking, torsion and vibration strength, furnished in the longest practicable length. Bolts, nuts and washers at screwed joints shall be of heat resistant material with guaranteed properties, suitably fixed and secured in order to not get loose under thermal stresses. All screwed joints shall be tinned or silver plated.

The outer enclosure shall be of the self-supporting type. The enclosure shall be fitted with drain plugs at the lowest points. Penetrations through walls, floors, etc., shall be covered after erection ensuring air tightness and matching of the adjacent surfaces. The material of gaskets shall be heat, water and dust proof. Insulators or screwed joints shall be accessible for inspection with minimum dismantling work required.

The insulators shall be designed and built to safely withstand all forces imposed under normal operation and under any kind of short-circuits. Fixing of the insulators at both the conductor and phase enclosure shall be provided with expansion joints to allow for thermal expansions due to temperature differences.

The generated heat shall be transferred by natural radiation and convection. No forced air cooling shall be provided.

The principle arrangement of the bus bars is shown in the powerhouse drawings.

Temperature rise

The maximum temperature attained by any part of the equipment when in service at site under continuous full load / maximum load conditions with maximum ambient air temperature shall not exceed the permissible limit:

- Conductor temperature 85°C
- Enclosure temperature 65°C

4.5 Technical data

Number of bus duct systems	1
Number of phases	3
Frequency	50 Hz
Operating voltage	15.8 kV
Rated voltage, voltage class (IEC)	24 kV
Test voltage 50 Hz, 1 min.	50 kVrms
Impulse test voltage 1/50 µs	125 kVpeak
Voltage variations:	± 6 %
Nominal current	9,500 A[4]
Nominal current at -6% Un	10,107 A
Nominal current for excitation branch*)	100 A
Rated current for branches to station service transformer and SFC*)	1000 A
Cooling system	AN
Duty cycle	Continuous
Maximum short-circuit current (rms value, 1 s)*)	72 kA
Maximum short-circuit peak current *)	188 kA

[4] All equipment of the motor-generator switchgear and connected equipment must not exceed the thermal limits at continuous operation at Un -6%.

Maximum short-circuit current (rms value, 1 s) for branch*)	124 kA
Maximum short-circuit peak current for branch*)	326 kA

*) indicative, values has to be determined by the contractor during detail design phase

4.6 Isolated Phase Bus ducts

4.6.1 General

The three-phase connection with the co-axial watertight isolated phase bus ducts comprises a conductor (aluminum A5 -99.5 %) centered in a conductive sheath (aluminum A5 -99.5 %) acting both as a screen and protective covering.

All material and parts shall be sound, without manufacturing flaws or erection faults, with welded seams having been planned. Their dimensions and tolerances are fixed by the drawings and usual standards.

In all welding applications the high quality electrodes shall be used. They shall be prepared, welded, cleaned and treated in accordance with regular standards to give homogeneity in material and perfect water-tightness. The aluminum sections shall be welded under an argon atmosphere.

4.6.2 Conductors

The conductor comprises an aluminum tube or double skin aluminum profile, which can be made to form a regular open polygon.

The joints between the conductor elements within the enclosures shall be welded, as well as the expansion joints made from aluminum strip.

For the connections to the electrical equipment’s it is necessary to use either a light alloy having the required quality and characteristics and totally inert to oxidation, or an antimagnetic steel also inert to oxidation.

The conductors shall be painted externally with a coat of mat black paint, increasing their radiant heat dissipation capacity and improving their natural cooling.

4.6.3 Insulators – support structures

The insulators, placed radial within the enclosure, support and center the conductor, assuring the required level of insulation. The insulators, which are made of porcelain or cast araldite, are individually accessible from the exterior.

4.6.4 Enclosures

The enclosures, fully welded from one end to the other, must be guaranteed both watertight and dust-proof.

In accordance with installation requirements expansion bellows are foreseen which, to maintain the continuity of the enclosures, comprise aluminum A5 and are welded between two enclosure elements.

The enclosures are electrically star-connected to one another and are grounded at their both ends.

The interior surface of the enclosure shall be painted with a coat of mat black paint in order to facilitate the absorption of the calories dissipated by the conductors.

The exterior surface of the enclosure shall be painted with a coat of mat green paint, the complete link system being situated within the powerhouse.

4.6.5 Frames/Support Structures

The frame supports have to permit either a free expansion of the busducts or enable perfectly rigid fixed points to be made. These frames are painted, or galvanized, or built from an aluminum alloy.

4.6.6 Grounding

A grounding bus shall be provided (area not less than 120 mm² copper conductor). It shall extend along the full length of the bus housing and shall be bolted, brazed or welded to the framework of each bus unit, the supporting structure and power plant earth system.

4.6.7 Pressurisation of the IPBs

In order to eliminate the risk of having condensation occurring within the enclosure, a system maintaining a pressure of 1005 to 1020 mbar shall be provided. The complete compressor system for each bus duct run shall be supplied.

4.7 <u>IPB connections</u>

4.7.1 Generator Connections

Since the isolated busducts are made of aluminum and the terminals of the machines are made of copper, it is necessary in all cases to make an aluminum-copper adaptor.

To avoid excessive temperature rises on the contact surfaces, such connection should be made with great care. For this reason, the Contractor should supply the tinned copper or silvered braids for the ends of the aluminum conductors, which are connected to the equipment terminals. For the connections to the transformers (which are replaceable), the manufacturing tolerance of the interchangeable machines must be taken into account.

The neutral connection (star point), shall be made with IPB incorporates three (3) 2-core current transformers of ring type. For generators with parallel stator windings there shall be one 1-core current transformer between the star points of the different layers. The secondary windings connected to the terminal boxes fixed to the enclosures.

The grounding system has on net side a ‘rigid star point’ earthing and on generator side a resistance/impedance earthed star point. Additionally there is a disconnector switch to disconnect the star point formation from the generator resistance grounding.

For the mounting of one voltage transformer and one resistor, one steel or aluminum sheet casings, placed on the ground, are foreseen. One medium voltage cable will connect this cubicle to the star point formation. The grounding current shall be limited to approximately 10A. The short time rating shall be 20 sec.

4.7.2 Transformer Connections

3 cylindrical aluminum sleeves placed around the terminals achieve the screening of the terminals. These casings and sleeves must have sealed connections between the transformers and the enclosures (by the introduction of flexible bellows in Neoprene or similar material) to take the relative expansions between these two elements into account.

The dimensions of the transformer flange shall be determined and agree

4.8 Other Bus Connections

The excitation transformer, braking switch, current limiting reactors, lightning arrestor and voltages transformer cubicle described hereunder, shall be provided with flanges for connection to isolated phase bus. The bus manufacturer shall provide the required flexible connectors, flexible joints, flanges and hardware to connect the buses to these equipment’s.

4.9 Generator Circuit Breaker (GCB)

The generator circuit breaker enclosure shall mainly include one circuit breaker, disconnector for SFC starting bus and grounding switches, measurement transformer, capacitor, and surge arrestor as required by the Contractor design (see also chapter 4.16). All these equipment shall be installed in an isolated phase type enclosure providing a continuous enclosed area with the bus duct.

The circuit breaker shall be Vacuum type, with all three poles simultaneously operated by a common operating mechanism of the trip free type, fitted with an anti-pumping device. A count of circuit breaker operations shall be provided to SCADA. A mechanical operations counter shall also be provided on each circuit breaker.

The mechanical life shall be at least 20,000 OC.

The mechanism shall be equipped with a mechanical indicator showing position of the circuit breaker.

The circuit breaker operating mechanism shall be fitted with 1 closing coil 220VDC, 3 independent tripping coils 220VDC and 12 pairs of auxiliary contacts used for the control circuit (220VDC). The tripping solenoid shall operate reliably down to a voltage of 65% of rated operating voltage.

The surge arresters and capacitors for each generator shall have the characteristics specifically suited to the protection of alternating current rotating machines. The surge arresters shall be of metal oxide gapless type and shall conform to IEC 60099-4. These shall be shunted by protective capacitors. The capacitors shall be of explosion proof design and shall be provided with built in discharge resistors.

The main technical data are:

Operating voltage	15.8 kV
Rated voltage	24 kV
Nominal current at Un	9500 A
Test voltage 50 Hz, 1 min.	50 kVrms
Impulse test voltage 1/50 µs	125 kVpeak
Rated short circuit symmetrical breaking current generator sourced*)	63 kArms
Rated short circuit symmetrical breaking current grid sourced*)	100 kArms
Mechanical operations	20,000 CO

*) indicative, values has to be determined by the contractor during detail design phase

4.10 Phase reversal switch

For the operation of switching from generator to motor operation and vice versa a 5-pole phase reversal switch in the block dissipation between generator circuit breaker and main transformer shall be installed.

The phase reversal switch shall be installed in an arc fault proved cabinet assemble and has to fulfil the following conditions:

- Three phase, six (5) pole, metal enclosed switch with a visible isolating distance
- Manual actuation for emergency operation, including a lockable metallic locking
- Natural cooling
- High-power connections to bus duct system with flexible joints, screwed

- The operating mechanism of the phase reversal disconnector shall be 3-phase ganged operated, electrically. The operating mechanism shall be suitable for 220 V DC power supply, and the phase reversal disconnector shall operate reliably at 80-110% of the rated voltage. The DC motor circuit shall be provided with necessary motor circuit contactors, thermal protection etc. The power supply for the DC motor shall be fed from the unit 220 V DC distribution board.

- The phase reversal disconnector shall be provided with a local control switch for "generating-off-pumping" and with locking devices at each operating location. It shall be forbidden to carry out direct phase reversing operating when the local control switch is on "generating" or "pumping" position. Electrical interlocking devices shall be provided for preventing mal operation.

- The disconnectors local control panel shall be provided with following controls:
  (i) Local/remote selector switch;
  (ii) Local open/close push button;
  (iii) Auxiliary contacts for open and close commands from remote;
  (iv) Auxiliary contacts for local and remote indications for open and close position;
  (v) Local and remote indications for circuit healthy, open / close status of the switches.

- Each set of phase reversal disconnectors shall be provided with mechanical position indicator and indication lamp for unit operation mode (generating-off-pumping), and an inspection window in the enclosure for visually inspecting the contact position.

- Each set of phase reversal disconnectors shall be provided with a numerical counter for counting the number of operations. The counter shall be wired to the unit control system.

- An earthing switch shall be provided on the main transformer side of the phase reversal switch to be used during maintenance. The earthing switch shall be of the rotary blade type, motor driven, with emergency manual drive, and shall be electrically interlocked to avoid earthing a live bus. No making or breaking capabilities are required for the earthing switch.

- Inspection window for visual inspection of the switch contact position shall be provided.

Any necessary framework structures for mounting / installation of the switch have also to supplied.

The main technical data are:

Operating voltage	15.8 kV
Rated voltage	24 kV

Nominal current at Un	9,500A
Test voltage 50 Hz, 1 min.	50 kVrms
Impulse test voltage 1/50 µs	125 kVpeak
Rated short circuit withstand current (1 s)*)	72 kArms
Mechanical operations	20,000 CO

*) indicative, values has to be determined by the contractor during detail design phase

4.11 Optional Design: Second GCB

The system supplier shall review, check and prepare a separate price item for the proposal for below defined optional design.

A concept with a second GCB instead of one GCB and one phase reversal switch may be offered. The technical data for the second GCB is the same as for the GCB described above.

4.12 Braking switch

The unit will be equipped with a braking switch.

This device shall make a solid short circuit between all 3 phases for the field tests and electrical braking of the unit. The braking switches shall be placed in suitable non pressurized aluminum or carbon steel cubicles with non-magnetic IPB entry section, with an electrical operating mechanism supplied by 220 V DC. In view of the frequent duty of the stator short-circuit switch, special attention shall be given to prevention of undue wear of contacts and shock during operation.

The short time rating of the stator short circuit switch shall be selected carefully considering the time required to brake the unit at motor-generator rated stator current and shall include reasonable margin.

Electrical interlocking shall be provided between the generator circuit breaker and the stator short circuit switch. The control of the braking sequence shall be arranged such that the stator short circuit switch opens or closes only when the main field circuit-breaker and the dynamic braking field switch are open, and sufficient time has elapsed for the generator field current to fall to almost zero.

The switch operating mechanism shall be fitted with 8 pairs of auxiliary contacts used for the control circuit (220 VDC).

The following basic accessories shall be provided and mounted on each local control cabinet:

(i) Position indicator, marked OPEN/CLOSED, visible through the cabinet door;

(ii) Local/remote selector switch with position indication lamp;

(iii) Push button for local operation;

(iv) Contacts for remote operation / indication; and

(v) Isolating links for the control circuit supply.

Adequate grounding and short circuit connections shall be implemented.

The stator short circuit switch shall be housed in a metal enclosure suitable for connection with the IPB. The terminals of the switch shall be connected to the IPB conductors.

The main technical data are:

Operating voltage	15.8 kV
Rated voltage	24 kV
Rated current *)	8,000[5] A
Test voltage 50 Hz, 1 min.	50 kVrms
Impulse test voltage 1/50 µs	125 kVpeak
Rated short circuit withstand current (1 s)*)	72 kArms
Mechanical operations	10,000 CO

*) indicative, values has to be determined by the contractor during detail design phase

4.13 Current limiting reactors

The unit bus bar system shall be connected with a branch to three single-phase current limiting reactors for limiting the symmetrical three phase short circuit current from the bus bar branch to a value of about 25 kA.

Note: The dimensions of the coil-flange shall be determined and agreed between the Contractors of the isolated bus bars and the current limiting coils.

It is expected that each of the current limiting reactors shall be housed in a metal enclosure. If it is not possible to house them in an enclosure resulting into direct access to live parts, the Contractor shall provide necessary safety fence around this equipment.

In case of provision of air core reactors, the Contractor shall provide shielding to reduce the stray magnetic field.

The main technical data are:

[5] Equivalent to 20min braking with rated current in one hour.

Operating voltage	15.8 kV
Rated voltage	24 kV
Nominal current*)	1000 A
Rated short circuit current before reactors*)	124 kArms
Rated short circuit current after reactors	<25 kArms
u_{k*}*)	3.5 %
Insulation class	F
Air cooled	

*) indicative, values has to be determined by the contractor during detail design phase

4.14 Generator Neutral and Grounding Cubicle

One neutral cubicle is specified for the motor-generator. This cubicle will contain the current transformers, the generator neutral point, a disconnector switch (if necessary), a neutral grounding resistor, associated voltage transformer and all necessary interconnecting conductors.

4.15 Measurement transformers

The measurement transformers shall correspond to the specifications in Section 1 “General Technical Specifications” and the requirements of the General Technical Specifications.

The characteristics are defined in the protection system single line diagram drawing number MAN/BD/ED/05/003.

4.16 Measuring and Surge Protection Cubicle

Voltage transformers shall be single-pole insulated, with the star point earthed at the primary and secondary sides, unless required otherwise. Voltage transformers shall be integrated within the generator circuit breaker assembly and the phase reversal switch assembly. Primary side windings shall be earthed via a removable link to a common terminal for earthing core and frame.

The Contractor shall take necessary measures to prevent mal-operation of the protection and measurement circuits due to DC and other high frequency AC voltage which may be impressed on the voltage transformer neutral ground points during SFC operation.

The surge protection devices shall comply with the requirements of IEC 60099-5 for protection of the generator winding against surges and shall be rated by the Contractor based on insulation coordination studies and approved by the Employer.

The surge voltage protection devices shall be integrated with the generator circuit-breaker assembly.

Three single-pole surge capacitors shall be provided to reduce the steepness of the prospective over voltages.

The location, arrangement and equipment for surge protection shall be determined after the electromagnetic transient studies by the contractor.

The arrester shall be equipped with a discharge recorder.

4.17 Inspections and Tests

4.17.1 Factory Tests

The raw materials to be used in the construction shall be checked in respect to their mechanical and electrical properties. They shall be manufactured, except in particular cases, in accordance with the prescribed standards at either the Contractor's or his sub-contractor's workshop. Welds shall be checked at regular intervals, notably for water-tightness, by an accepted well-proven method.

The Contractor shall furnish the test reports on the insulators and the quality control of the aluminum especially from the point of view of purity and resistivity.

Power frequency withstand test and insulation resistance measurement on generator circuit breaker cubicles, braking switches and on representative sections of bus ducts as per relevant standards.

The measuring transformers shall be calibrated for the rated primary and secondary current, the phase displacement and the voltage shall be checked in the primary and secondary windings.

Mechanical inspection and functional tests on generator circuit breakers, phase reversal switches, braking switches.

4.17.2 Field Tests

4.17.2.1 Bus Ducts

Following tests are to be carried out:

- Checking of mechanical clearances, dimensions, levels, etc.
- Alignment and connection check
- Phasing, continuity and insulation tests
- Continuity of grounding
- Measurement of resistance

- Loading, the Contractor shall test the impedance and the resistance of the bus bars.

- The Contractor shall test the dielectric characteristics of the entire generator switchgear/busducts combination referring on the 24 kV voltage class, with power frequency voltage of 40 kVrms for 1 minute.

4.17.2.2 Generator Circuit Breaker and Cubicle Assemblies

Following tests are to be carried out:

- Alignment and connection check
- Voltage, continuity and insulation tests on auxiliary, control and instrument transformer circuits
- Mechanical operation tests
- Function tests on operating devices and circuits including full verification of the electrical interlocking scheme
- Instrument transformer tests
- Current injection tests
- Electrical resistance of current path tests
- Calibration of monitoring instruments
- Air pressure leakage tests
- Stored energy system test
- Timing tests
- Power frequency withstand voltage tests

4.17.2.3 Phase reversal switch, braking switch and earthling switches

- Functional test
- Interlocks test

4.18 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

4.19 Documentation

4.19.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

4.19.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Main Single line diagram HV, MV	Design Drawing	3
Arrangement and layout	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Generator Circuit Breakers (GCB) assembly outline	Design Drawing	3
GCB cubicles outline	Design Drawing	3
Neutral cubicle outline	Design Drawing	3
Isolated phase busduct (IPB) outline	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
IPB Weight, wiring diagram, bill of materials	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Technical data GCB, IPB, phase reversal switch, braking switch	Technical Report	10
Current limiting reactors	Technical Report	10
Wiring diagrams generator neutral and grounding cubicle, GCB, phase reversal switch	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15

Electrical calculations and characteristics	Technical Report	10
Inspection and test plan	Technical Report	15
Operation instruction and maintenance handbooks	Technical Report	2 months before commissioning

5 MEDIUM VOLTAGE SWITCHGEARS

5.1 General Description

For the station service power supply there will be one 15.8 kV switchgear in the powerhouse, two 22 kV switchgears in the powerhouse and one 22 kV switchgear in the upper reservoir operating building. The 15.8 kV switchgear in the powerhouse is fed from the unit over current limiting reactors. The first 22 kV switchgear in the powerhouse is for the connection to the emergency diesel generator, the second one for the IEC back up supply. The 22 kV switchgear in the upper reservoir operating building will be supplied from the local 22 kV IEC grid.

The indoor switchgears shall be metal enclosed, vermin proof, dust proof, partition class PM, service continuity category LSC 2B, internal arc classification A FLR, top internal arc included, protection degree IP41 and shall comply with the requirements of latest edition of the International Electromechanical Commission (IEC).

The MV switchgear shall be compartmentalized, with separate compartments for circuit-breakers and busbars. Cables, current and voltage transformers can exist in the same compartment.

The withdrawable vacuum circuit breaker shall be equipped with facilities for remote operation and shall be operable in withdrawn test position. The circuit breaker unit shall be equipped with local On / Off push buttons and an indicator showing the position of the breaker in the control room.

The grounding switches shall be rotary blade types, air-insulated, motor-driven with optional manual drives, and shall also be integrated with the circuit breaker switch into the same enclosure. Grounding switch operation shall be remote and local controlled and interlocked with the circuit breaker.

Overcurrent, overload, overvoltage, under-voltage and ground fault protection shall be provided. The tripping of the circuit breaker shall be indicated in the power plant control and monitoring system. Ground fault detection shall lead to a warning only, no direct tripping is envisaged.

The Contractor shall determine the final ratings of the bus bars, circuit-breakers, instrument transformers and other auxiliary devices associated with the MV switchgear.

5.2 Scope of Supply

One (1) 15.8 kV switchgear in the powerhouse, single bus system

Two (2) 22 kV switchgears in the powerhouse, single bus system

One (1) 22 kV switchgear in the upper reservoir operation building, single bus system

All following feeders shall be equipped as a minimum with withdrawable circuit breaker, grounding switch, surge arresters, CTs and VTs, overcurrent protection, overload protection, ground fault protection and metering equipment connected to the bus bars.

5.2.1 15.8 kV switchgear feeder powerhouse

- Current limiting reactor of unit
- Static frequency converter
- Station service transformer 1
- Station service transformer 2
- Bus bar coupling
- Measuring
- Spare feeder (not equipped)

5.2.2 22 kV switchgear 1 feeder powerhouse

- Disconnector feeder to 22 kV line from local IEC grid
- Station service transformer 3
- Measuring

5.2.3 22 kV switchgear 2 feeder powerhouse

- Disconnector feeder 22 kV line to diesel unit transformer
- Station service transformer 4
- Measuring

5.2.4 22 kV switchgear feeder upper reservoir operating building

- Incoming feeder to 22 kV line from local IEC grid
- Station service transformer
- Measuring
- Metering
- Spare

5.3 Standards

The equipment under this section shall comply with the provisions and requirements of the latest approved recommendations of the International Electromechanical Commission (IEC), each as they apply.

5.4 Technical data

5.4.1 15.8 kV switchgear in the powerhouse

Design	Primary, air insulated Extendable LSC2B Metal enclosed, PM
Double bus bar system	
Location of erection	indoor
Rated voltage	24 kV LIST 2, according IEC 62271-200
Operating voltage	15.8 kV
Rated frequency	50 Hz
Number of phases	3
Rated AC test voltage	50 kV
Rated impulse test voltage	125 kV BIL
Rated current of the bus bars	1000 A
Rated short time current (3 s)	25 kA rms
Rated peak withstand current	63 kA
Internal arc classification	AFLR 25 kA / 1 s
Enclosure	RAL 7035

Technical Data of the Circuit Breaker:

Type	Vacuum
Rated voltage	24 kV
Rated short circuit breaking current symmetrical	25 kA
Rated short time current (3 s)	25 kArms
Rated peak withstand current	63 kA

Rated voltage of motor drive	230 V AC, 220 V DC

The circuit breakers comply with the specifications for AC switchgear for voltages above 1 kV, DIN VDE 0670, Part 101..108 and Part 1000 and IEC publications 56 and 694.

5.4.2 22 kV switchgears in the powerhouse and upper reservoir operating building

Design	Primary, air insulated Extendable LSC2B Metal enclosed, PM
Single bus bar system	
Location of erection	indoor
Rated voltage	24 kV
Operating voltage	22 kV
Rated frequency	50 Hz
Number of phases	3
Rated AC test voltage	50 kV
Rated impulse test voltage	125 kV BIL
Rated current of the bus bars	630 A
Rated Short time current (3 s)	25 kA rms
Rated peak withstand current	63 kA
Internal arc classification	AFLR 25 kA / 1 s
Enclosure	RAL 7035

Technical Data of the Circuit Breaker:

Type	Vacuum
Rated voltage	24 kV
Rated short circuit breaking current symmetrical	25 kA
Rated short time current (3 s)	25 kA
Rated peak withstand current	70 kA
Rated voltage of motor drive	230 V AC, 220 V DC

The circuit breakers comply with the specifications for AC switchgear for voltages above 1 kV, DIN VDE 0670, Part 101..108 and Part 1000 and IEC publications 56 and 694.

5.5 Inspections and Tests

5.5.1 Factory Tests

As a minimum the following tests shall be performed:

- Dielectric tests
- Calibration and test of current transformers and voltage transformers
- Functional tests and mechanical inspection

5.5.2 Field Tests

The field inspections and tests shall include at least:

- Alignment and connection check
- Phasing, continuity and insulation tests
- Continuity of grounding
- Dielectric tests
- Measurement of resistance and voltage drop
- Voltage, continuity and insulation tests on auxiliary, control and instrument transformer circuits
- Function tests on operating devices and circuits including full verification of the electrical interlocking scheme
- Instrument transformer tests
- Current injection tests
- Electrical resistance of current path tests
- Calibration of monitoring instruments
- Power frequency withstand voltage tests

5.6 Spare parts

The requirements are defined in the General Technical Specifications.

5.7 Documentation

5.7.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

5.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Single line diagram of MV with preliminary ratings	Design Drawing	3
Preliminary Arrangement and layout	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Single line diagram of MV	Design Drawing	8
Arrangement and layout	Design Drawing	8
Complete wiring diagrams of all cubicles	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15

Electrical calculations and characteristics	Technical Report	10
Interlocking scheme	Design Drawing	10
Equipment design data/technical load data and heat dissipation	Technical Report	10
Erection, assembly, shipping and handling instructions	Technical Report	12
Inspection and test plan	Technical Report	12
Protection Setting and alarm list	Technical Report	10
Operation instruction and maintenance handbooks	Technical Report	2 months before commissioning

6 400 VAC SWITCHGEARS AND LV BUS BAR SYSTEMS

6.1 General description

The power plant station services involve all the mechanical and electrical supplies and distribution circuits, which are necessary to enable the high voltage equipment and all its auxiliary electrical parts to function satisfactorily.

6.1.1 Categories of Station Services

The station services are classified in three categories, as follows:

- Essential services are those, which maintain mainly the Control and Monitoring System and Emergency Lighting in operation. They shall be available at all times and shall not be affected by any fault on a high or medium voltage circuit, or by a possible shutdown of the main power supply.

  This uninterruptible power supply (UPS) feeds first of all:

  - Control and monitoring system of the power plant
  - Signaling and protection circuits
  - Telecommunication equipment
  - Emergency lighting
  - Other essential consumers.

  These services feed the above consumers either directly, with direct current provided by a battery-set, or indirectly with alternating current generated by DC/AC inverter supplied by the 220 V DC batteries.

- Priority services for those consumers where a short interruption of power supply can be tolerated.

  Typical consumers fed by this supply:

  - Oil circulating pumps
  - Governor oil pumps
  - Dewatering and drainage pumps
  - Cooling water pumps
  - Battery-charger system 1
  - Unit transformer fire protection
  - Elevators
  - Emergency air-conditioning (cooling)
  - Control room

  These services feed the above consumers with alternating current from the Station Services' main supply. When the main supply fails the feeding is taken over by the diesel generator.

- Normal services are those, which are not affected by shutdown of long duration. Their no availability has any immediate influence on the power plant operation.

  They mainly feed:

  - Battery charger system 2
  - Lighting system
  - Powerhouse cranes
  - Air-conditioning and heating system
  - HP and LP air compressors
  - Machine-tools in workshops
  - Machine hall crane
  - Power receptacles
  - Etc.

  These services feed the above consumers with alternating current, from the Station Services' main supply. Except of the emergency part of the ventilation system the diesel generator unit will not supply this service.

6.1.2 Basic Principles of Design

For the above mentioned services a single bus bar system with longitudinal sections has to be used. The emergency diesel unit is connected to the essential bus bar. The contractor shall implement also a possibility to directly connect the local 22 kV supply to the essential busbar.

General and unit Station Services in the power plant are designed to satisfy the following criteria:

- Two redundant station service transformers connected to the 15.8 kV medium voltage switchgear in the powerhouse for supply of the main low voltage distribution boards in that area
- One station service transformer connected to the 22 kV medium voltage switchgear in the powerhouse
- One station service transformer connected, via 22 kV medium voltage switchgears, to the 400 VAC emergency diesel supplied switchgear in the switchyard operating building
- The design of the systems will easily allow to cut-off the normal service consumers, when the AC supply is switched to the diesel generator supply.

6.1.3 Operation of the Station Service AC Power Distribution System

The rating of the station service transformers are enough to fully supply the station service with only one transformer.

The parallel operation of the station service transformers is not allowed, so a hard wired interlocking between these transformers has to be implemented. Only one is feeding the bus bar. Depending on the availability of voltage the selection of the station service transformer is coordinated from the control system.

In case of no supply from the station service transformers, the diesel generator in the switchyard operating building is used to feed the essential loads.

6.2 Scope of Supply

One (1) 400 VAC low voltage main switchgear in the powerhouse

One (1) 400 VAC low voltage main switchgear in the operating building

One (1) 400 VAC low voltage main switchgear in the upper reservoir operating building

Four (4) isolated busbar systems for connecting the 400 VAC to the station service transformers 1, 2, 3 and 4 in the powerhouse

Two (2) lots MCC distribution boards in the powerhouse for essential auxiliary supply of the unit

Two (2) lots MCC distribution boards in the powerhouse for non-essential auxiliary supply of the unit

Necessary reactive power compensation for 22 kV connection according to IECo connection requirements

One (1) lot distribution boards in the powerhouse

One (1) lot distribution boards in the operating building

One (1) lot distribution boards for the upper reservoir operating building

One (1) distribution board for the upper reservoir intake

One (1) distribution board for the upper reservoir bottom outlet

One (1) distribution board for the lower reservoir intake

One (1) distribution board for the lower reservoir bottom outlet

One (1) distribution board near the surge tank

One (1) distribution board near the flexible joint (dewatering pumps)

One (1) lot of special tools, devices, equipment required for operation and maintenance of the system

In a general way, all internal wiring and cabling of switchgears, as well as cable links between draw-out switchboard cells, shall be part of this Specification.

Besides the manufacturing of station services switchboards and works directly related to these, it is the Contractor's responsibility to ensure in every respect the proper operation of all station services. This includes the understanding that an important part of the requirements will involve studies and designs regarding station services as a whole.

The complete set of tools for erection troubleshooting and maintenance for the station services. The complete itemized list of tools shall be submitted to the Owner for approval. The list shall contain the names, quantities and technical descriptions of the tools to be provided.

6.3 Standards

The equipment under this section shall comply with the provisions and requirements of the latest approved recommendations of the International Electromechanical Commission (IEC), each as they apply.

6.4 Design particulars

The basic requirements for the equipment are listed in the General Technical Specifications.

6.4.1 Technical data main switchgear

Rated voltage	400/230 V, 3 phases, N, PE
Rated frequency	50 Hz
Control voltage	220 V DC, 24 V DC (for remote control)
Dielectric test voltage	2.5 kV, 50 Hz, 1 min.
Powerhouse	
Single bus bar system	
Grid form	TN-C-S
Connection of supply	3-phase, 4-wire
Connection of consumers	3-phase, 5-wire

Rated short time withstand current I_{cw} (1 s)	77 kA[6]
Circuit breaker service breaking capacity I_{cs}	80 kA

Operating building

Single bus bar system with sectional disconnection

Grid form	TN-S
Connection of supply	3-phase, 5-wire
Connection of consumers	3-phase, 5-wire
Rated short time withstand current I_{cw} (1 s)	40 kA
Circuit breaker service breaking capacity I_{cs}	40 kA

Upper reservoir operating building

Single bus bar system with sectional disconnection

Grid form	TN-C-S
Connection of supply	3-phase, 4-wire
Connection of consumers	3-phase, 5-wire
Rated short time withstand current I_{cw} (1 s)	25 kA
Circuit breaker service breaking capacity I_{cs}	25 kA

The components of each cubicle shall be coordinated by the Contractor safely to withstand the effect of closing, carrying and interrupting any sort of current up to the short-circuit rating.

6.4.2 Technical data distribution boards

Grid form	TN-S
Single bus bar system	
Rated voltage	400/230 V, 3 phases, N, PE
Rated frequency	50 Hz
Connection of supply	3-phase, 5-wire

[6] In case of both station service transformers are in parallel operation. If this mode is not necessary according to Contractor detail design the values decrease accordingly.

Connection of consumers	3-phase, 5-wire
Control voltage	220 V DC, 24 V DC (for remote control)
Dielectric test voltage	2.5 kV, 50 Hz, 1 min.

Powerhouse

Rated short time withstand current I_{cw} (1 s)	80 kA
Circuit breaker service breaking capacity I_{cs}	80 kA

Operating building

Rated short time withstand current I_{cw} (1 s)	40 kA
Circuit breaker service breaking capacity I_{cs}	40 kA

Upper reservoir operating building, upper and lower reservoir intake and bottom outlet, flexible joint and surge tank

Rated short time withstand current I_{cw} (1 s)	25 kA
Circuit breaker service breaking capacity I_{cs}	25 kA

The components of each cubicle shall be coordinated by the Contractor safely to withstand the effect of closing, carrying and interrupting any sort of current up to the short-circuit rating.

6.4.3 Low Voltage Busbar System

The 400 VAC connection from the 1600 kVA station service transformers to the 400 VAC main switchgear in the powerhouse is realized with a low voltage busbar system.

Rated isolation voltage acc. IEC 61439-1	1000 V
Rated operating voltage	1000 V
Rated frequency	50 Hz
Rated current	2500 A
Conductor material	Copper
Number of conductors	L1, L2, L3, PEN (100% sized)
Busbar surface treatment	Isolated along entire length
Trunking unit material	Aluminium casing

Rated short-time withstand current (1 s)	80 kA
Rated peak withstand current	203 kA
Degree of protection	IP55
Colour of trunking and tap-off unit	RAL 7035

Copper conductors in aluminium casing including all junction units, distribution board connecting units and transformer connecting units.

6.4.4 Main Equipment

Rating of bus bars, circuit-breakers, current and voltage transformers, isolating switches, isolating fuse switches etc. shall be determined by the Contractor according to the load connected and protection system used.

6.4.5 Interlocking conditions

Circuit breakers of the station service transformers and diesel generators shall be interlocked to avoid the parallel operation. An additional interlocking is installed to avoid the parallel operation of the station service transformers.

6.4.6 Protection

Selective protection system shall be provided by means of electronic thermal- and overcurrent (instantaneous and short time delayed) relays or fuses.

All devices shall be lightning surge protected by a coordinated system according to EN 62305 (SPD II/III).

6.4.7 Provision for Remote Control and supervision

In addition to requirements given under control and monitoring systems the following must be provided:

- All circuit breakers shall be provided for remote control and remote position indication
- Record measuring of bus bar voltages of all LV switchboards.

6.5 Inspections and Tests

In addition to the inspections and tests specified in the General Technical Specifications.

- Dielectric tests
- Functional and operational tests
- Measurement of the insulating resistance of the different power and control circuits, including cables, instruments and apparatus

- Adjustment of the protection equipment
- Resistance measuring of all major circuits and grounding

6.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

6.7 Documentation

6.7.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

6.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Single line diagram 400 VAC	Design Drawing	3
Arrangement and layout	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Low voltage bus ducts	Design Drawing	6
Complete connection and interconnection diagrams of all equipment in station service	Design Drawing	10
Complete wiring diagrams of all cubicles	Design Drawing	10

Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Electrical calculations and characteristics	Technical Report	10
Interlocking scheme	Design Drawing	10
Material/Equipment specification and technical design data	Technical Report	10
Technical load data and heat dissipation	Technical Report	10
Electrical consumer list / Motor starter list	Technical Report	10
BOQ/Component lists	Technical Report	10
Inspection and test plan	Technical Report	12
Protection setting and alarm list	Technical Report	10
Cable lists	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 months before commissioning

7 DC AND UNINTERRUPTABLE POWER SUPPLY

7.1 General Description

For the general description for this chapter please see chapter 6.1 of this specification.

7.2 Scope of Supply

220 VDC power supply main distribution boards

- One (1) lot in the powerhouse
- One (1) lot in the operating building
- One (1) lot in the upper reservoir operating building

220 VDC power supply sub distribution boards:

- One (1) lot in the powerhouse
- One (1) lot in the operating building
- One (1) lot in the upper reservoir operating building
- One (1) lot in the upper reservoir intake
- One (1) lot in the upper reservoir bottom outlet
- One (1) lot in the lower reservoir intake
- One (1) lot in the lower reservoir bottom outlet

220 VDC power supply batteries and rectifier:

- One (1) lot in the powerhouse
- One (1) lot in the upper reservoir operating building

220 VDC power supply voltage stabilizer:

- One (1) lot in the upper reservoir bottom outlet
- One (1) lot in the lower reservoir intake
- One (1) lot in the lower reservoir bottom outlet

60 VDC power supply including DC/DC converter, distribution boards:

- One (1) lot in the powerhouse

48 VDC power supply including DC/DC converter, distribution boards:

- One (1) lot in the powerhouse
- One (1) lot in the operating building

230 VAC uninterruptable power supply main distribution boards, sub distribution boards:

- One (1) lot in the powerhouse
- One (1) lot in the operating building
- One (1) lot in the upper reservoir operating building

230 VAC uninterruptable power supply inverters:

- One (1) lot in the powerhouse
- One (1) lot in the upper reservoir operating building

One (1) lot of special devices, tools, maintenance equipment etc., required for installation, testing, commissioning and maintenance of the batteries, chargers, inverters, UPS and distribution systems

The scope shall include all components and other systems which are required for performance, durability and satisfactory operation of the equipment even though not individually or specifically stated in these specifications.

7.3 Standards

The equipment under this section shall comply with the provisions and requirements of the latest approved recommendations of the International Electromechanical Commission (IEC), each as they apply.

7.4 Battery chargers

The following provisions and requirements shall be applicable for all battery chargers.

Solid-state rectifiers shall be used throughout, every one capable to supply 100 % of the rated load.

The design of the charger shall be such that it can supply simultaneously the full power requirements of the DC network connected to the battery in addition to the 10 hours recharging current of the completely unloaded battery.

The chargers shall be completely equipped for a fully automatic and controlled floating charging of the batteries, and shall be of the voltage-regulated type with current limiting device.

The chargers shall be mounted in enclosed, dust-proof cubicles.

7.5 Batteries

The batteries shall be of the lead acid type, the individual cells completely closed, provided each one with its own acid level indicator (floaters) and provided with acid spray preventing vent plugs. The polarity of the battery shall be engraved and easily legible.

Maintenance accessories such as thermometer, measuring device for the sulphuric acid, bottles for acid and pure water, etc. shall be supplied.

Technical data 220 V batteries powerhouse:

Number of batteries	2
Rated voltage	220 V
Type	GroE or OPzS
Number of cells	108
Rated voltage per cell	2 V

Minimal capacity:

Sufficient to supply a current of 140 A during 8 h (by 2 systems), the voltage of the DC network (measured at bus bar of the main distribution) during this operation shall not be less than 92 % Un. After consideration of the increasing factors for aging (1.25), temperature correction (1.08), conversion factor 8h/10h (1.06) design margin (1.1) a minimal battery capacity of 900 Ah per battery shall be used.

Both batteries shall be arranged in one level only.

Technical data for 220 V battery system in the upper reservoir operating building.

Number of batteries	1
Rated voltage	220 V
Type	OPzV
Number of cells	18
Rated voltage per cell	12 V

Minimal capacity:

Sufficient to supply a current of 30 A during 8 h, the voltage of the DC network (measured at bus bar of the distribution) during this operation shall not be less than 92 % Un.

The battery cells shall be arranged in a cubicle.

7.6 220 VDC Voltage Stabilizing

According the length of the 220 VDC cables to the 220 VDC distribution boards in

- Lower reservoir bottom outlet
- Lower reservoir intake
- Upper reservoir bottom outlet

a stabilizing of the 220 VDC voltage is needed.

This stabilizing is realized with 2 redundant DC/DC converter 220/220 VDC at each location. These converters operate in parallel via coupling diodes, and are arranged in the corresponding distribution board.

Each converter can supply 100 % of the rated load, is mounted in a 19 inch chassis, has a output voltage constancy of at least ± 1% static and ± 4% dynamic and allows a input voltage variation of at least 160 VDC to 260 VDC. The design must allow fulfilling the power requirements with a design margin of at least 30%. The converter are AN cooled. In case of a short circuit at the output the converter must supply a short circuit current of at least 200% of the rated current for at least 2 s. After that the converter must safely switch off.

7.7 Inverters

The following provisions and requirements shall be applicable to the 220 V DC / 230 V AC inverters.

Two static inverters connected in parallel, each one capable to supply 100 % of the rated load and with a maximum harmonic distortion of 5%. The inverters shall be supplied from the 220 V DC batteries; the design must allow fulfilling the power requirements of the uninterruptable AC network with a design margin of at least 30% and must prevent any non-allowed load conditions for the battery.

Each converter must be resistant against short circuits, surges and spikes. Each shall be designed and constructed so as not to cause interference with radio reception or telephone communication circuits. Each inverter shall be AN cooled and shall be provided with a contact for remote annunciation of output voltage failure. The voltage regulation capability shall be ± 5% at power factor 0.8.

The inverters shall be completely equipped for a fully automatic operation.

7.8 220 V DC Distribution Boards

7.8.1 Design Data

Rated voltage	220 V DC

Short circuit rating for equipment shall be as follows:

Main distribution:	12 kA
Sub distributions:	6 kA

7.8.2 Main Equipment

- Rating of bus bars, circuit breakers, isolating switches, isolating fuse switches, etc. shall be determined by the Contractor according to the load connected and protection system used.
- Silicon diodes used in battery chargers and for coupling shall be rated for no less than 400 V inverse crest voltage.

7.8.3 Protection

- Voltage relays (27/59) shall be provided. On the bus bar system the following voltage levels shall be detected:

- Highest voltage	220 V +15 %
- Lowest voltage	220 V -15 %
- Setting range for each alarm level	± 10 %

- Earth fault detection system (64) is to be provided for the main DC switchboard.

7.8.4 Provision for Remote Control and Supervision

In addition to requirements given under Control and Monitoring Systems, power and load centres shall be provided for:

- Remote indication of all alarm levels, voltage-drop and fault detection described above
- Tele measuring of bus bar voltage and battery-currents.

7.9 48 VDC and 60 VDC Distribution Boards

The generation of the 48 VDC and 60 VDC power will be locally realised via two redundant DC/DC converters feeded from the 220 VDC supply. These converters operate in parallel via coupling diodes.

These converters, the sub distribution via miniature circuit breakers, measuring equipment, over-, under voltage indication; earth fault indication will be installed in electrical cubicles.

7.9.1 Design Data

Rated voltage — 48 VDC and 60 VDC

Short circuit rating for equipment shall be as follows:

Main distribution: — 6 kA

Sub distributions: — 3 kA

7.9.2 Main Equipment

Rating of bus bars, circuit breakers, isolating switches, isolating fuse switches, etc. shall be determined by the Contractor according to the load connected and protection system used.

7.9.3 Protection

- Voltage relays (27/59) shall be provided. On the bus bars system the following voltage levels shall be detected:
  - Highest voltage — Ur +15 %
  - Lowest voltage — Ur -15 %
  - Setting range for each alarm level — ± 10 %
- Earth fault detection system (64) is to be provided for the DC switchboards.

7.9.4 Provision for Remote Control and Supervision

In addition to requirements given under Control and Monitoring Systems, power and load centers shall be provided for:

- Remote indication of all alarm levels, voltage-drop and fault detection described above
- Tele measuring of bus bar voltage

7.10 230 V Uninterruptible Power Supply Distribution Boards (UPS)

7.10.1 Design Data

Rated voltage	230 V AC, 50 Hz

Short circuit rating for equipment shall be as follows:

Main distribution	6 kA
Sub distribution	3 kA

7.10.2 Main Equipment

Rating of bus bars, miniature circuit breakers, isolating fuse switches, etc. shall be determined by the Contractor according to load connected.

The main distribution board is permanently connected in parallel to the normal AC supply and DC/AC inverters via fast electronic switches enabling the covering of demand peaks from the AC main. In case of AC supply failure the whole essential load is taken over by DC/AC inverters supplied from 220 V batteries.

7.10.3 Protection

- Voltage relays (27), and (59) shall be provided. On the bus bar the following voltage levels shall be detected:
  - Highest voltage 230 V + 6 %
  - Lowest voltage 230 V - 6 %
  - Setting range for each level 10%

7.10.4 Provision for remote Control and Supervision

In addition to requirements given in Control and Monitoring Systems, the following shall be provided:

- Remote indication of all alarm levels and voltage drop
- Tele measuring of bus bar voltages and AC main feeder current.

7.11 Inspections and Tests

In addition to the inspections and tests specified in the General Technical Specifications.

- Functional and operational test
- Measuring of insulating resistance of power and control circuits

- Adjustment of protection equipment
- Battery test

7.12 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

7.13 Documentation

7.13.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

7.13.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Single line diagram 220 VDC, 230 VAC UPS	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Battery outline	Technical Report	3
Inverter outline	Technical Report	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10

Complete wiring diagrams of all cubicles	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
Battery drawings	Design Drawing	10
Rectifier and inverter drawings	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Electrical calculations and characteristics	Technical Report	10
Material/Equipment specification and technical design data	Technical Report	10
Electrical consumer list	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 months before commissioning

8 EMERGENCY DIESEL GENERATOR

8.1 General description

In case of emergency the diesel generators will supply important services which help to shut down the plant in a safe way. The diesel generator set for the upper reservoir operation building will feed the 400 VAC switchgear for the upper reservoir area. The diesel generator set for the operating building will feed the 400 VAC switchgear.

8.2 Scope of Supply

One (1) 50 kVA diesel generator unit near the upper reservoir operation building installed in a container

One (1) 50 kVA diesel generator unit near the operating building installed in a container

The scope of supply for each diesel generation unit consists of:

- Basic engine:
  Motor block and generator with shaft, oil pump with measuring unit and motor mounting fetes.
- Regulation
- Lubrication:
  Pressure lubrication with oil filter including first filling with engine oil
- Fuel system:
  Fuel injection pump, fuel filter, fuel tank and flexible connections for fuel pipes
- Induction system:
  Air filter mounted
- Exhaust system:
  Exhaust manifold with flange and counter-flange
- Electric equipment:
  Electric starter with battery, charging alternator, supervision and indication for oil pressure and cooling water temperature, diesel generator circuit breaker, synchronization device for testing, metering and control devices.
- Radiator - mounted:
  Front-type radiator with pusher-fan, mechanically driven by belts, air duct, and finger protection grill, expansion tank as well as piping system between radiators and engine.
- Ventilation system of the diesel generator room

- Container
  All above mentioned components are installed in a container for outdoor assembly

- Documentation:
  Instruction manual, electrical schematics, terminal diagrams, cable lists, connection lists, device lists, layout drawings, one fold

8.3 Standards

ISO 3046	Reciprocating internal combustion engines
IEC 60034-1	Rotating electrical machines – rating and performance
IEC 60034-5	Rotating electrical machines – degrees of protection provided by the internal design of rotating electrical machines (IP code)
DIN 6280	Generating sets - Reciprocating internal combustion engines driven generating sets

8.4 Design particulars

The diesel generator (DG) shall be designed for continuous operation and for long periods of standstill.

The diesel generator unit shall supply automatically the auxiliary equipment in the event of failure of the normal 400 V AC. Manual mode of starting and shut down shall be possible. Starting of the DG unit shall be possible without external auxiliary power supply.

The diesel generator is realized as brushless internal pole synchronous alternator with damper winding and integrated excitation.

Provisions for a test run under full load in parallel with the 400 VAC distribution system shall be provided.

The diesel generating set will be installed in a container near the upper reservoir operating building.

Assembly

Engine and alternator are rigidly connected with intermediate flange and mounted on a common base frame. Coupling for power transmission from engine to alternator. The generating set shall be completely tested, painted and mounted. Provision shall be made to avoid transmission of dangerous vibrations to the supporting structures.

The control panel shall be installed separately from the diesel generating sets.

8.5 Technical data

Generator

Painting	RAL 5010
Overload acc. to DIN 6280	10%
Rated power factor [cosphi]	0.8
Rated voltage	400/230 V
Rated power acc. to DIN ISO, continuous load	50 kVA
Rated frequency	50 Hz
Connection	star
Voltage range	+/- 5%
Rated speed	1500 min^{-1}
Insulation class	F
Protection degree	IP 31
Radio interference	N
Unbalanced load	100%
Phase sequence	right
Cable outlet	AS right
Cable outlet	with pull relief

Motor

Painting	RAL 5007
Rated power diesel motor acc. to DIN ISO, continuous	40 kW
Type of Engine	4 stroke diesel
Charging	Turbo
Cylinder layout	V
Number of cylinder	8 or 12
Rated speed	1500 min^{-1}

8.6 Construction of Emergency Diesel Generator

8.6.1 Diesel Engine

The diesel engine shall be of heavy duty type to continuously drive the electric generator at the speed of 1,500 rpm maximum, solid injection, compression ignition, exhaust gas turbo charged with inter-cooler, water-cooled closed circuit with radiator, battery starting, four stroke, multi-cylinder with changeable cylinder liners, forced oil lubrication with cooler, mechanical or hydraulic governor, exhaust silencer with necessary piping.

8.6.2 Governor

The governor shall be of the mechanical-hydraulic type without any electronic components. Between 10 % and 100 % of the rated output, the steady load speed band shall not exceed 1 % of the rated speed.

External means of adjustment of the nominal speed setting by ±5 % at all loads between 0 and 100% load shall be provided.

8.6.3 Cooling System

The diesel engine shall be water cooled by means of a closed water cooling system. Proper inhibitors shall be added in the water to protect the cooling system against corrosion and sludge.

The water shall be boosted by a centrifugal pump fitted on the engine, it shall be cooled by a fan directly driven by the engine. The radiator shall be rated for a maximum ambient temperature of 50°C.

8.6.4 Exhaust System

The exhaust system shall include the silencer, manifold, expansion joints, flexible couplings, the pipe insulation, a drainage pipe and all fittings.

8.6.5 Fuel tank System

The capacity of the main storage tank shall be

- 2000 liters

The tank shall be equipped at least with the following:

- one level gauge
- high and low level limit switches
- necessary connections for filing, emptying, drainage, with aeration valves, rupture discs, etc
- necessary shut-off valves, isolating valves, drainage valve, etc.

- one special connection for fuel oil sampling, and
- lifting lugs

8.6.6 Ventilation System

For diesel-generating-set consisting of:

- 2 pcs. weather protection grills for air in and outlet opening
- 2 pcs. automatic louvres in galvanized steel incl. servomotor, for installation in the air in/ and outlet opening of generating room
- 1 pc. steel sheet duct in galvanized steel, between radiator and air outlet opening

8.6.7 Sound Attenuators

75 dB(A), consisting of:

- Sound attenuators for mounting in the air inlet opening
- Sound attenuators for mounting in the air outlet opening
- Installation of special sound absorbers in the exhaust pipe system

8.6.8 Generator

The AC generator shall be of constant voltage, 50 Hz, three phase, air cooled, self-excited, brushless type. Damper windings shall be uniformly distributed around the rotor. The generator shall be able to withstand 1.2 times the rated speed. Type of duty is S1 as defined in IEC 60034-1

The star point of the generator shall be solidly grounded.

Control board

Closed switchboard in steel sheet construction with swing doors including indication- and operating instruments on the front side with wiring diagram kit.

Cable connection:

- from the bottom by screwing or by cable ducts

In particular it must include:

- the generator protection
- the current transformers
- the circuit breakers and contactors for the auxiliaries (fuel oil pump, preheating, etc.)

- the protection and auxiliary relays for the diesel engine
- the Automatic Voltage Regulator
- the synchronizing equipment
- the selector switch for local/remote operation of the diesel generator unit
- the selector switch for manual/automatic test run modes
- the push-button switches for starting/stopping the unit and auxiliaries
- the electrical indicators for current, voltage, frequency and power
- the indicators for the diesel engine: oil pressure, temperatures, speed, etc.
- the operation and fault signaling lights
- the protection relays

The operation of each protection shall be indicated by a flashing light on the local control panel and a sound alarm.

Battery starting system

- Starter Battery

  Consisting of:
  - 1 battery: capacity 150 Ah, voltage 24 V
  - 1 battery-charging device, type: PMC 12/24-20
  - 1 battery voltage supervision (load supervision)
  - 1 voltmeter

- Control Battery

  Consisting of:
  - 1 battery: capacity 150 Ah, voltage 24 V
  - 1 battery-charging device, type: PMC 12/24-20
  - 1 battery voltage supervision (load supervision)
  - 1 voltmeter

8.6.9 Control and Monitoring

The emergency diesel generator unit will be supplied with their own control, protection and monitoring system. Signal exchange with the power plant control and monitoring system as well as the respectively main distribution boards has to be ensured for control and interlocking purposes.

The generator protection shall trip the associated circuit breaker in the respective distribution board. Protection circuits must be hardwired.

8.7 Inspections and Tests

8.7.1 Factory Tests

The following special tests and checks shall be carried out in the Contractor’s shops:

- All functioning and guarantee tests (as for example load-test, fuel-consumption test, efficiency-test etc.) as required by the Contractor’s practice or by applicable standards during the manufacture stage
- Performance tests on the assembled diesel generating set (with voltage regulator)
- Functional tests on the fuel transfer pump (if any)
- Dielectric and insulation tests
- Routine tests on voltage regulator
- Hydrostatic pressure test on fuel tank (at 2 bar)

8.7.2 Field Tests

The following special tests shall be carried out after installation at the site:

- Operational tests (including instantaneous loading and load rejection)
- Measurement of the output
- Functional testing of all alarm devices
- Checking of the starting time and of the time up to taking-over full load.
- Vibration test

8.8 Spare parts

The requirements are defined in the General Technical Specifications.

8.9 Documentation

8.9.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

8.9.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Diesel generator schematics	Design Drawing	3
Diesel tank Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Electrical calculations and characteristics	Technical Report	10
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12

Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 months before commissioning

9 CONTROL SYSTEM

9.1 General Description

This control system is to facilitate the operation of the PSPP Manara power plant. It comprises local and remote control, display and data logging facilities of the whole process. State of the art automation systems shall be provided for all plant equipment to allow both local control and control from the control room and load dispatch centre.

An overview of the Control System for the PSPP Manara is shown in drawing no. MANARA/BD/ED/05/002.

For overall monitoring, display and logging a SCADA system will be provided. The equipment supplied should conform to the common technical requirements.

Automation systems must be distributed in individual process stations that all have autonomous controllers for specific subsystem. All subsystem components are interconnected with a redundant process network to allow data transfer between stations. Safety related information must not however rely on this data highway but dedicated channels must be used (e.g. hard-wired). Substations must also stay functional (keep their current state) in case of network outage.

9.2 Scope of Supply

9.2.1 Networks

One (1) GPS clock system including antenna and over voltage protection, connected to the LAN

Two (2) Routers for access to the WAN

Two (2) Routers to connect the LAN of the operating building with the LAN of the cavern

Two (2) Routers to connect the LAN of the operating building with the LAN of the upper reservoir intake area

Two (2) Routers to connect the LAN of the operating building with the LAN of the lower reservoir intake area

One (1) Modem and necessary equipment to provide an additional communication gateway over public telephone network

One (1) piece of SNMP software installed on the engineering system

One (1) Set of fiber optical cables to build up the fiber optical rings and connections in the operating building, cavern, upper reservoir intake area and lower reservoir intake area

One (1) Set of fiber optical cables to build up redundant fiber optical connections to the cavern, upper reservoir intake area and lower reservoir intake area.

One (1) Set of fiber optical cables from the switchyard control building to the IECo metering room in the powerhouse. These cables shall be dedicated for IECo, the type of the cables will be provided by IECo at a later time.

One (1) Set of splice boxes (where needed/as required)

One (1) Set of switches (where needed/as required)

One (1) Set of Ethernet cables to connect the devices (where needed/as required)

Two (2) Server racks for installation of SCADA equipment

Two (2) SCADA-servers including 24" flat screen, keyboard and mouse

Two (2) Operator stations each with two 24" flat screens, keyboard and mouse

One (1) Mobile engineering station with an additional 24" flat screen, keyboard and mouse

One (1) A3 Color printer with network interface

One (1) A4 Laser printer with network interface

One (1) Power supply cubicle with miniature circuit breakers and 220 VDC / 24 VDC converters

One (1) Router for remote access in case of maintenance or trouble shooting. The remote access shall protected by a firewall according Israeli cyber security standards

One (1) NAS back-up server for archiving, information management, monitoring and data back-up storage

One (1) alarm system with acoustic sounds, optical indication etc.

9.2.2 Operating building Control System

9.2.2.1 Station Service and Auxiliaries Control System

One (1) Cubicle for Auxiliaries

One (1) Cubicle for low voltage station service

One (1) Set of Cubicles with Remote I/O's

9.2.2.2 Central Station Controller

One (1) Cubicle for installation of the Central Station control equipment including accessories

One (1) set of discharge sensors and pressure sensors for the water level measurement

9.2.3 Cavern Control System

9.2.3.1 Station Service and Auxiliaries Control System

One (1) Cubicle for Auxiliaries

One (1) Cubicle for low voltage station service

One (1) Cubicle for medium voltage station service

One (1) Set of Cubicles with Remote I/O's

9.2.3.2 For power generating unit

One (1) Cubicle for Auxiliary power supply including accessories

One (1) Cubicle for installation of the unit control equipment including accessories

One (1) additional control cubicle (if needed)

One (1) Cubicle with Remote I/O's for generator

One (1) Cubicle with Remote I/O's for turbine

9.2.4 Upper reservoir intake area Control System

9.2.4.1 Station Service and Auxiliaries Control System

One (1) Cubicle for Auxiliaries and auxiliary power supply including accessories

One (1) Cubicle for low / medium voltage station service

9.2.4.2 Bottom Outlet / Intake Control System

One (1) Cubicle for installation of the bottom outlet and intake control equipment and auxiliary power supply including accessories

9.2.5 Lower reservoir intake area Control System

9.2.5.1 Station Service and Auxiliaries Control System

One (1) Cubicle for Auxiliaries / low voltage station service and auxiliary power supply including accessories

9.2.5.2 Bottom Outlet / Intake Control System

One (1) Cubicle for installation of the bottom outlet control equipment and auxiliary power supply including accessories

One (1) Cubicle for installation of the intake control equipment and auxiliary power supply including accessories

9.2.6 Control Room Furniture

One (1) Control desk for 3 operator’s positions

Five (5) Operator chairs

Three (3) Documentation cabinets

Two (2) Printer trolleys

Two (2) Small-size tables

One (1) Video wall and enclosure of video wall with access door

One (1) Time display

Any other items not explicitly listed but necessary for making the system complete and necessary to fulfill the required control and monitoring functions, e.g. but not limited to communication ports, remote terminal units, I/O modules, smart terminators, etc.

Only field-proven standard systems and components will be accepted. They shall be interchangeable with other products of similar type.

9.3 Networks

The individual functional areas of the power plant shall be interconnected by local networks. A fundamental distinction in this regard is made between the operating building LAN (henceforth known as the operating building process LAN) and the computer LAN (henceforth known as the HMI LAN).

A redundant switched Fast Ethernet LAN (100 Mbit/s technology compliant with IEEE 802.3) shall be provided for this purpose. All single faults in the different process LAN’s shall be handled without data loss or functional impairment. In the event of multiple faults, the functional areas must be able to continue operating without causing mutual interference. The functional areas shall be implemented as peer nodes on the process LAN. This ensures short response times between command output and feedback in the entire control system.

Communication between the functional areas of the power plant and the control center system must be based on the TCP/IP network protocol.

The 161 kV switchyard should be connected directly to the process LAN of the operating building.

Digital protective devices and equipment in switchgear control systems that communicate over IEC 60870-5-103 or IEC 61850 shall be connected to the process LAN by means of related interfaces.

An Ethernet ring bus in the form of a LAN shall be provided for the cavern process LAN and shall be connected via two redundant fiber optic links and two switches to two Industrial Ethernet routers of the process LAN in the operating building.

Another Ethernet ring bus in the form of a LAN shall be provided for the upper reservoir intake area. The upper reservoir process LAN shall be connected via two redundant fiber optic links and two switches to two Industrial Ethernet routers of the process LAN in the operating building.

Additional an Ethernet ring bus in the form of a LAN shall be provided for the lower reservoir intake area. The lower reservoir process LAN shall be connected via two redundant fiber optic links and two switches to two Industrial Ethernet routers of the process LAN in the operating building.

The implementation of the field bus systems to connect the bay controllers and remote I/O’s shall be based on Ethernet with deterministic communication protocol.

A protocol such as Modbus or Profibus may be used for linking in transducers and other sub systems with the process station acting as the master.

The contractor shall provide all fiber optic connections as well as the associated network components and accessories in accordance with the Control System topology.

9.3.1 Connection to the wide area network (WAN)

9.3.1.1 Primary communication path

The contractor shall provide a connection path to the wide area network using a redundant pair of industrial routers.

Splice boxes shall be used as interfacing equipment between fiber optical cabling of the plant and inter plant fiber optical medium. These splice boxes are included in the scope of contractor’s supply.

9.3.1.2 Secondary communication path

In case the physical wide area network connection becomes unavailable there must be a secondary communication path using public switched telephone network over a modem connection.

9.3.2 Network cabling

Data transmission paths in the local area shall be implemented by default as multimode fiber optic cables for portions outside a row of adjoining cabinets. In the installation of the power plant LAN, attention shall be given to routing the return path of the fiber optic ring over different paths (and where possible in different fire compartments).

Single mode fiber optical cable shall be applicable for the connection to the switchyard.

9.3.2.1 Fiber optic cables

Fiber optic cables with at least two G62.5/125µ fibers, dual splitters and two flexible ends, for the most part preassembled with connectors, shall be used in the LANs. The cables shall have glass roving for rodent protection.

A closed fiber optic ring is a prerequisite for achieving the required functional redundancy of the process LAN.

9.3.2.2 Electrical LAN cabling

Network-capable components shall be connected using 10/100 Base-T screened unshielded twisted pair (S/UTP) cable (Cat 5 or better) with RJ45 connectors. To allow the higher transmission reliability of S/UTP cable to be utilized effectively in the power plant, the RJ45 connectors must also be screened versions.

9.3.3 Switches

Only Industrial Ethernet switches may be used in the networks. The switches shall be powered redundantly either from 24 VDC or 230 VAC UPS. Using a fast redundancy mechanism, a replacement path shall be activated within 0.3 s after failure of a network component. Failure of a network component shall not lead to network failure.

Redundant equipment, such as server pairs, main and reserve systems, etc. shall be linked to the LAN concerned by separate switches.

The switches must support SNMP and Web management and must have functional monitoring with a floating status contact (relay contact, closed-circuit principle) to enable reporting of the failure of at least one of the two redundant supply voltages, a faulty link status of one of the two backbone ports, a persistent internal fault or a self-test error.

9.3.4 Remote maintenance

There shall be a remote connection possibility for system management and maintenance during project execution and warranty period. This remote connection shall be implemented over the WAN-connection between the plant and the remote dispatch center.

9.3.5 Time synchronization

Time management in the entire automation system and/or the performance capability of the functional units shall be designed such that all necessary automation and monitoring tasks are fulfilled.

The time management functions in automated systems handles time setting for real-time clocks and keeps these real-time clocks synchronized. An NTP time server with GPS receiver shall be used for central time acquisition.

The overall concept of the process-level control system is based on the idea that in every system module, every automation component that must perform a time-dependent function has a clock with suitable accuracy (maximum error 10 ms) and resolution. These clocks are set by a system data package.

Time setting may take place:

- automatically by the time server of the automation network
- automatically by a time-transmitting automation component with the current time
- by repeated forwarding of a time setting data package from the time setting source until it reaches the lowest level of the automation network.

9.3.6 Network management

For availability reasons and to enable rapid localization of fault sources, network component monitoring, which means monitoring of the switches, routers, etc., should be an integral part of the SCADA system.

The network should be monitored using the TCP/IP-based Simple Network Management Protocol (SNMP). It must be possible to exchange all relevant data, such as status, performance, faults, alarms and reports, using the standardized SNMP protocol.

The resulting messages are represented by normal process variables in the SCADA system PCC (plant control center) as well as LDC (load dispatch center) and thereby made available in the same way as external process data (further processing possible, display on screens, in lists, alarm generation, etc.).

9.4 Control System Hierarchy

The operation authority increases with increasing process proximity. This means that the local user interface has the highest authority and the remote human-machine interface (HMI) has the lowest authority. A user interface with higher operation authority can assume command authority for a system (machine cluster, switch cubicle, pump, etc.) from a user interface with lower operation authority.

9.4.1 Load Dispatch Center

The highest HMI level is the Load Dispatch Center (LDC). The LDC has the lowest priority (P5) and can control operation when all lower-level HMIs have set their operation authority to remote.

The 161 kV switchyard system forms an exception to this rule. In accordance with the operational control agreement, it is largely operated from the Grid Control Center (GCC) of the responsible power grid operator.

9.4.2 Control Room

The next lower HMI level is the Power plant Control Center (PCC), which has workstations in the control room. The control room is situated in the operating building. The PCC has priority P4 and can control operation when all lower-level HMIs have set their operation authority to remote.

The PCC consists of two independent computers (SCADA clients), which are connected over an Ethernet HMI LAN to the redundant SCADA servers.

The process monitoring screens show the process state and guide the operator with dynamic overlays in the form of symbols, graphics and text. Process changes are displayed on the screen immediately. It must be possible to control and monitor all units using standardized object-oriented control panels.

9.4.3 Local control panels

The underlying HMI level consists of the Unit Control Panels, the Low / Medium voltage station Control Panels and the Bottom Outlet / Intake Panels. These HMIs control operation when their own operation authority is set to local and all lower-level HMIs have set their operation authority to remote. The local panels have priority P3.

A 19-inch touch screen shall be used for each local control panel. Only the minimum necessary number of LEDs, indicators and buttons shall be used in addition to the touch screen.

9.4.4 On-site panels

The next lower HMI level is the on-site panels (OSPs), such as the control panels in the exciter cabinet and the turbine control cabinet and on the field control devices of the switchgear system branches. These HMIs control operation when their own operation authority is set to local. The OSPs have priority P2.

9.4.5 Direct actuation level

The direct actuation HMI level consists of controls (such as switches and buttons) for individual units, such as the cooling water pump or bearing oil pump. These HMIs give operators direct access to process operations. These HMIs have priority P1.

9.5 Automation devices

The devices in the process control level must fulfill the following basic tasks:

- Monitoring, data acquisition and data preprocessing for analog and binary transducer signals.

- Output and monitoring of command circuits. Non-executed commands must be reset.
- Monitoring of undesirable position changes (limit faults, un-commanded motion)
- Monitoring actuators for tripping of speed-dependent limit switches in case of mechanical faults
- Output and monitoring of set point values
- Monitoring of internal system functions
- Control, monitoring and protection functions; interlock logic
- Automatic starting, stopping, control and load change functions for units
- Power plant control functions, such as automatic water management, automatic machine control, automatic weir deployment, etc.
- Data exchange with the higher-level control center system and other functional areas over the process LAN
- Process visualization and operator control using touch panels
- Graphic programming interface compliant with IEC 61131-3 with online display and simulation of I/O signals

9.5.1 Digital signal input and signal processing

The following requirements apply to all modules provided for digital signal acquisition:

- Digital signals are galvanic isolated from the voltage level at which they reach the automation device, preferably by opto-couplers, and further processed at the system voltage level.
- The input voltage (sensing voltage) is 24 or 220 VDC as appropriate in each case.
- The input voltage (sensing voltage) is fused or otherwise protected in the corresponding functional unit.

9.5.2 Digital signal output

The following requirements apply to all modules provided for digital signal output:

- Relays or opto-couplers shall be used to convert commands from the system voltage level to the equipment voltage level (command voltage).

- Floating outputs shall be provided. The command voltage (24 or 220 VDC) for aggregates and switching devices shall be switched by these floating contacts.
- Important commands (for circuit breakers, load-break switches, etc.) shall be implemented as two-pole.

9.5.3 Analog measurement value input and processing

As a matter of principle, only three-wire or four-wire transducers shall be used. The auxiliary voltage for the transducers shall be fused or otherwise protected individually for each functional group (e.g. turbine, generator, etc.).

Current-output transducer signals (4–20 mA) shall be connected to the automatic control system and monitored. External current-output signals shall be galvanic isolated from locally situated transducers by supply voltage isolators or isolation amplifiers. Attention shall be given to the provision of suitable overvoltage and lightning surge protection for current-output measurement signals external to the powerhouse (e.g. level measurements), matched to the type of transducer used.

9.5.4 Analog measurement output

Analog measurement values are output to the process for the output of set point values or the display of measured values. Isolation amplifiers shall be used as necessary. Analog values shall be output with galvanic isolation.

9.5.5 Direct converter input

As an alternative to electrical measurement data acquisition (current, voltage, active and reactive power) using transducers, a converter input module complying with the following specifications may be provided.

The converter secondary circuits shall be connected directly to the system without intermediate connection of measurement value converters or intermediate converters. The converter signals shall generally be connected to the system via isolation/test terminals.

The following quantities shall be derived from the acquired values by calculation:

- Effective value
- Active power
- Reactive power
- Power factor
- Line voltage or phase voltage

The frequency range shall be at least 45–55 Hz.

Power calculation shall be performed using either the two-wattmeter or the three-wattmeter method, user selectable. The previously calculated active and reactive power shall be used for power factor calculation.

Resolution and accuracy:

Measurement accuracy: Current and voltage	0.2%
Active and reactive power:	0.5%
Resolution:	12 bits

9.5.6 Temperature measurement

The resistive temperature sensors shall be connected only with three-wire or four-wire via suitable Pt100 modules.

Resolution and accuracy:

Measurement accuracy:	0.25%
Resolution:	12 bits

9.6 Power Supply

The power distribution to each control station is supplied by two feeds from both main distribution points at 220 VDC and if needed, by one feed each from the central distribution for 230 VAC / UPS and 230 VAC / emergency supply. In order to ensure full functionality, even if the 220 VDC supply should fail, a local rectifier fed by the 400 VAC distribution is also provided.

Both 220 VDC feeds are connected to two bus bars by one switch each, which are decoupled by diodes and joined by a common, secure 220 VDC bus, from which the loads are supplied via line circuit breakers.

Two 220 VDC/ 24 VDC converters are supplied by one 220 VDC bus bar each. The secondary sides of these are joined by diode decoupling at a common, secure 24 VDC bus, by which the loads are supplied via line circuit breakers.

The following principles apply to the distribution and number of circuit breakers.

- Each functional unit (process station, switch, etc.) is supplied by a dedicated drop from the sub distribution.
- The monitoring and command voltages are divided into sensible groups and protected separately. Grouping is done to ensure maximum availability of all system components.
- All circuit breakers have auxiliary contacts that are input to the process stations. They are generally captured as individual signals.

9.7 Operating building Control System

9.7.1 Station Service and Auxiliaries Control System

9.7.1.1 General

The auxiliary and station service systems should, to the extent possible, have independent automation, and are primarily monitored by the super ordinate control system. There are essentially the following systems:

- One 220 VDC main distribution
- One 230 VAC / UPS main distribution
- Fire alarm system
- Intrusion alarm system
- Building services with heating and air conditioning (HVAC and lighting)

Operation and monitoring must be performed by the control system for the switchgears and switchboard sections listed below.

- 400 / 230 VAC main distribution with 1 busbar and a coupling
- Transformer 0.4 / 0.95 (0.69) kV, 100 kVA
- 400 VAC emergency power diesel system, 50 kVA

The process I/O requirements are given below include the required reserves.

	DI	DO	AI	PT 100	AO
Auxiliaries	102	16	14	8	
Low voltage station service	80	24	14		

9.7.1.2 Automation units

One automation unit for auxiliaries with primarily local I/O modules for connecting the auxiliary systems, 230 VAC main distribution and 220 VDC main distribution.

One automation unit for the low voltage station service with primarily remote I/O modules for connecting the 400 VAC main distribution and the 50 kVA emergency diesel aggregate.

9.7.1.3 Diesel emergency power system controls

The commands Parallel Operating Mode, Emergency Power Mode, Diesel Stop, Unlock (after protective switch is thrown) and Emergency Stop must be made available to the diesel emergency power system.

Using the Parallel Mode command, a parallel mode is initiated; that is, the diesel system can be switched to a live busbar via the corresponding synchronization device, and assigned a power level that can be set by parameters, for the purpose of performing periodic tests.

The emergency power mode is enabled by the Emergency Power Mode command. The diesel emergency power group can be started and connected automatically, if needed. In this case, ensure that only those system areas that are authorized to use emergency power get connected and that all emergency powered drives are switched on in a staggered manner when the power is restored.

9.7.1.4 Automatic switching

In normal, error-free operation, the 400 / 230 VAC main distribution is fed from the non-essential busbar of the 400 / 230 VAC distribution in the switchyard operating building. If this power fails, for example due to an error, then an attempt is made to switch to the essential busbar of the 400 / 230 VAC distribution in the switchyard operating building. If none of the sources is available the diesel generator is started automatically after a parameter-based delay, if both 400 VAC bus bars are switched to zero voltage and connected to the busbar

As soon as one of the two sources is available again, and the diesel system has been in use for a minimum time (that can be set by a parameter), the supply is switched back to the available source.

Automatic switchover to a specific source can be prevented by switching the associated feed switch to manual. This source is then no longer available to the automatic switchover system.

Automatic switchover can be prevented, in general, by switching all of the feed switches to manual.

9.7.2 Central Station Controller

9.7.2.1 General

The tasks of the station controller (Joint Controller) are:

- Simplifying power plant operation
  - Individual target values and operating modes define the operation of the overall system
  - Implementing (external) power timetables

- Optimizing unit utilization
  - Increasing system efficiency through optimal unit management
- Monitoring permissible operating ranges
  - Level limits, voltage ranges
- Automatic reaction if the permissible ranges are exceeded
  - Activating limit controllers for level, voltage
  - Endowment of residual flow

The Joint Controller must therefore include the following functions:

- Expanded control functions
  - cos φ control
  - Voltage control
- Basic control functions
  - Flow control
  - Active power control
  - Reactive power control
- Setpoint distribution
  - the unit
  - integrated actuator monitoring
- Special functions
  - Machine changeover function
  - Optimization of transfer procedures between units

The process I/O requirements are given below including the required reserves.

	DI	DO	AI	PT 100	AO
Central Station Controller	32	16	8		

9.7.2.2 Automation units

An independent automation unit must be connected to the process LAN for this functional package and for coupling the associated upper and lower level equipment, such as the reservoir level measurements, etc.

The following screens must be provided for operation and visualization of the Joint Control:

- Overview screen of Joint Control
- Screen of reactive power controller
- Screen of active power controller
- Screen of flow rate controller
- Screen of unit usage automatic
- Screen of parameters for unit operation

Overview screens for the power plant, process LAN, and HMI LAN are also required.

9.7.2.3 Flow distribution

Flow distribution assigns the amount of flow required by the flow controller to the available organs. The flow of the unavailable regulating devices (such as those in individual mode) is included, and changes are compensated by the available ones.

The required flow is distributed using the operating parameters and the availability of the regulating devices. The flow is passed to the regulating devices with the highest priority as much as possible. If a turbine is out of service, then the outflow quantity is distributed among the available turbines as a first priority by the Joint Control.

9.7.2.4 Units usage automatic

The units usage automatic serves to automatically start and stop units, depending on the active power set point (flow rate). The switching thresholds in the automation are selected so that the total efficiency of the power plant is maximized.

The start-up points for the units are calculated using the turbine efficiency curves, and are stored in the Joint Control as parameters. The optimal start and stop points are calculated offline.

In addition to automatic mode, semi-automatic mode should also be available. If a change in the number of units is required for efficiency purposes, then this is indicated in semi-automatic mode by an appropriate message for the affected unit at the Control Center System. In automatic mode, the affected unit is started or stopped automatically after a prescribed delay period.

The turbines are actuated by providing dynamic active power and flow rate targets to the unit control, and thus to the turbine controller. The operating state of the units is captured and applied by means of availability signals. The command and measurement circuits are monitored automatically.

The units assigned to the Joint Control are operated in active synchronized mode; that is, all openings are kept nearly identical, depending on the type of machine and the efficiency.

The future possibility of primary control of individual units must be kept open.

Configuration of head-dependent upper and lower limits for the flow control organs must be possible. The turbines are run by the Joint Control only in the prescribed opening range.

The units are placed into use according to an adjustable order. The prescribed priority settings define the sequence of starting and stopping the units. The unit with the highest priority is always running. Other units are started and stopped again, in order of decreasing priority.

The priority can be defined by the Control Center System. In case the priorities are reassigned, no immediate switching takes place. Only after the next switching point has been reached the switchover will be performed.

The reactive power distribution should be done according to cos φ; that is, the cos φ value is used for synchronizing the distribution logic. This ensures that, even if the active power is different for different units, the reactive/active-power ratio is not excessive.

The unit controller monitors to ensure that the maximum reactive power, according to the generator operation curve, is not exceeded. Active power and flow rate have priority, and reactive power is limited according to the generator operation curve.

The Joint Control receives an appropriate message from the machine controller if the reactive power has been limited, and distributes the difference to the non-limited units.

9.7.3 Staff Signalling System

For transmission of warning and alarm messages to the on-duty and on-call staff a staff signalling system shall be installed.

9.7.3.1 GSM Signalling System

The system should at least consist of 8 inputs with freely configurable text messages of each input, SMS notification, at least 20 receiver for each message, integrated phone book up to 100 numbers, status notification, GSM mobile phone network 850, 900, 1800, 1900 MHz.

8 output signals from the control system should be connected to this GSM signalling system.

9.7.3.2 Telephone, Radio Communication, Public Address System

The same 8 output signals than in 9.7.3.1 should be connected to the telephone, radio communication and public address system.

9.8 Cavern Control System

9.8.1 Station Service and Auxiliaries Control System

9.8.1.1 General

The auxiliary and station service systems should, to the extent possible, have independent automation, and are primarily monitored by the super ordinate control system. There are essentially the following systems:

- Two 220 VDC rectifiers, including battery feed
- Two 230 VAC inverters with electronic and manual bypasses
- Two 60 VDC rectifiers
- Two 48 VDC rectifiers
- One 220 VDC main distribution
- One 230 VAC / UPS main distribution
- One 60 VDC distribution
- One 48 VDC distribution
- Cooling water system
- Compressed air generation and distribution
- Fire alarm system
- Intrusion alarm system
- Building services with heating and air conditioning (HVAC and lighting)

Operation and monitoring must be performed by the control system for the switchgears and switchboard sections listed below.

- 15.8 kV feed via unit
- 15.8 kV switchgear
- 22 kV feed via 22 kV switchgear of the switchyard operating building
- 22 kV feed via switchyard operating building

- 400 / 230 VAC main distribution with 2 busbars (general and essential services), a coupling, and the 4 feeds listed below
    - Station service transformer T1 15.8 / 0.4 kV
    - Station service transformer T2 15.8 / 0.4 kV
    - Station service transformer T3 22 / 0.4 kV
    - Auxiliary power transformer 22 / 0.4 kV

The process I/O requirements are given below include the required reserves.

	DI	DO	AI	PT 100	AO
Auxiliaries	128	16	14	8	
Low voltage station service	80	24	14		
Medium voltage station service	80	16	14	4	

9.8.1.2 Automation units

One automation unit for auxiliaries with primarily local I/O modules for connecting the auxiliary systems, 230 VAC, 220 VDC, 60 VDC and 48 VDC main distribution.

One automation unit for the low voltage station service with primarily remote I/O modules for connecting the 400 VAC main distribution.

One automation unit for the medium voltage station service with primarily remote I/O modules for connecting the 15.8 kV switchgear (alternatively: combined bay controller and protection devices).

9.8.1.3 Automatic switching

Switching the feed source between the two units on the station service switchgear and the 22 kV feed from the switchyard operating building is done automatically in normal mode. Forced switchover can be performed using the corresponding selector buttons on the user interface. Switchover between the sources is performed using a zero-voltage 400 VAC busbar. That is, the active feed is first cut off, and then the selected feed is switched on. A feed can be selected only if it is available.

The three sources of supply, unit 1, unit 2 and 22 kV feed can be assigned priorities via the user interface.

In normal, error-free operation, the 400 / 230 VAC main distribution is fed from one of the two station service transformers. If this power fails, for example due to an error, then an attempt is made to switch to the next available source with the highest priority. If none of the sources is available, then the diesel emergency power system is switched to connect to those bus bars that require emergency power. The diesel generator is started automatically after a parameter-based delay, if both 400 VAC bus bars are switched to zero voltage.

As soon as one of the three sources is available again, and the diesel system has been in use for a minimum time (that can be set by a parameter), the supply is switched back to the available source that has the highest priority.

Automatic switchover to a specific source can be prevented by switching the associated feed switch to manual. This source is then no longer available to the automatic switchover system.

Automatic switchover can be prevented, in general, by switching all of the feed switches to manual.

9.8.2 Unit Control System

9.8.2.1 General

The unit functional area encompasses all control equipment that can be assigned to a unit. This includes in particular:

- Unit automation
- Mechanical protection
- Turbine controller (governor)
- Excitation
- Electrical protection
- Synchronization
- Speed sensing
- Vibration sensing

The process I/O requirements are given below include also the interfaces to the turbine control, the excitation and the electrical protection, however the I/O count as listed include no contingency for expansion.

	DI	DO	AI	PT 100	AO
Unit	352	160	32	32	8

9.8.2.2 Automation units

The following basic structure is specified for the automation unit of a turbine/generator unit:

- Module rack with sufficient spare bays
- Redundant power supply, 220 VDC and 24 VDC
- Central processor unit for the control functions with the necessary communication modules and associated central and local I/O peripheral modules
- Central processor unit for the monitoring functions (mechanical protection) with the necessary communication module and associated central and local I/O peripheral modules

As an alternative to a process station with two CPUs, two automation units may be used.

The automation components for the unit include the functional areas of the belonging unit transformer and the dedicated feed to the service station transformers.

The following screens shall be provided for unit operation and display:

- Overview screen of the machine unit with HMI panels
- Sequence screen for the start/stop automatic
- Screen for the unit auxiliary equipment
- Screen for the controller hydraulic system
- Screen for the lubricating oil system
- Screen for the cooling water supply
- Screen with generator and turbine diagram
- Screen for temperatures (bearings, generator, transformer, oil cooler, etc.)
- System monitoring screen

Multiple trends as specified by the Owner, an alarm message list and a chronological event list shall also be installed.

9.8.2.3 Operating modes

An operating mode selector switch with the settings Off, Test, Local and Remote shall be provided.

OFF

In this operating mode, which can only be selected locally by a key switch at the unit control station, commands are not issued by the control system. All command voltages are switched off. All application programs of the process station (including mechanical and thermal protection) act only passively.

TEST

Test mode is used for maintenance and servicing and can only be selected locally using a key switch at the unit control station. Only the minimum interlock conditions (primary interlocking) are active. These are fundamentally the same conditions as for manual operating mode. No commands are issued by the start/stop automatic to the ancillary unit controllers. Protection remains active without restrictions. The flow is set to zero. Individual operation of all auxiliary equipment from the touch panel is possible.

LOCAL

The following operating modes can be selected on the UCP touch panel:

- Local – Manual: Manual operation of all auxiliary equipment from the touch panel
- Local – Jog: Stepwise operation of a selected sequence from the touch panel
- Local – Auto: Initiation of a sequence from the touch panel and issuing of set point values to the turbine controller and excitation system for load changes

REMOTE

The following operating modes can be selected at both operator stations of the Control Center System (SCADA System) and the LDC:

- Remote – Auto: Operation under control of both workstations of the Facility Control Center (starting and stopping machines, issuing set points to the turbine controllers and excitation system for load changes)
- Remote – JC: Automatic operation under joint control (starting and stopping machines, issuing set points to the turbine controllers and excitation system for load changes)

9.8.2.4 Start/stop sequence

The start/stop automatic shall be implemented as an autonomous CPU (Control component) separate from the mechanical protection unit.

The start/stop automatic must provide all necessary control functions for starting and stopping the unit.

The tasks of this automatic in the Control component are essentially:

- Sensing operating conditions and startup conditions
- Implementing automated sequence control for the selected operation target
- Implementing manual operation HMI (step by step mode)
- Driving the unit auxiliary equipment and sub automatics
- Interface to turbine controller
- Interface to synchronization system
- Interface to excitation system
- Interface to electrical protection system
- Connection to the process LAN

9.8.2.5 Synchronization

A programmable synchronization device must be included for the following requirements:

- Suitable for outputting setting impulses to voltage and speed controllers
- Adjustable impulse / pause ratio
- Parameter set (circuit breaker time constants, tolerances for slip, voltage, etc.) stored in memory
- Zero-voltage setup for connecting feeds and generators to zero-voltage buses
- Dual-channel measurement circuit
- Dual-channel control of circuit breaker "on" command
- Measured value outputs for differential angle, speed difference, voltage difference, etc. for connection to indicators
- Transformer voltage 150 V, 50 Hz

- Power supply voltage matching the available battery voltage (220 VDC)
- External automatic acknowledgement
- Clearable operational signal
- Memory function for at least 5 synchronizations

The interface to the automation device should be made in parallel.

When synchronizing the generator to a live or non-live bus, the appropriate synchronization mode must be selected and the synchronization process initiated. The synchronization device is automatically started only after the lockout conditions have been cleared.

Synchronizer commands to raise/lower the speed or raise/lower the voltage go directly to the turbine controller and the excitation system. When the synchronization conditions have been met, the "on" command is given directly to the generator circuit breaker.

The synchronization process should be able to be monitored using a notebook with appropriate software.

9.8.2.6 Measurement

A digital multimeter with direct transformer coupling is provided for measuring the electrical variables of the generator circuit. Data transfer to the control system uses a local fieldbus (Modbus or Profibus).

The following minimum requirements apply to this multimeter:

- Multifunction measurement transducer with separate user interface and display for front installation
- Direct connections for 5 A or 1 A current transformers, voltage transformers 100 V to 500 V, each programmable
- Reference and output measurements, inductive and capacitive
- Measurement variables that can be displayed or transmitted to the control system by serial data connection are voltage, current, active power, reactive power, apparent power, cos ϕ, frequency
- Simultaneous display of at least 4 measurement variables on the user interface display (selected using buttons)
- Programming of the measurement transducer via the user interface, secured by password, or alternatively by means of a service program; in this case, the service program and connector cable are part of the scope of supply
- Serial fieldbus interface (Modbus or Profibus) for data transfer to the control system

- Analog measurement output (4-20 mA) for active power, for connecting to the turbine controller
- Where required, up to 4 analog measurement outputs for local display using indicator instruments
- Binary monitoring contact (closed-circuit principle)

9.8.2.7 Speed Monitoring

Speed monitoring should use 2 sensors. The analysis device must meet the following requirements.

- 6 speed contacts, including stop and slip speed monitoring, according to the controller, monitor, and lockout requirements
- Suitable interface to the turbine controller for controlling the speed
- Suitable interface (4-20 mA) to the control system for displaying the current speed
- Binary monitoring contact (closed-circuit principle)

The analog measurement value and all limit signals of the speed monitor, are captured and monitored in parallel by the mechanical/thermal protection.

An overspeed trip causes an emergency shutdown.

9.9 Upper reservoir intake area Control System

9.9.1 Station Service and Auxiliaries Control System

9.9.1.1 General

The auxiliary and station service systems should, to the extent possible, have independent automation, and are primarily monitored by the super ordinate control system. There are essentially the following systems:

- Two 220 VDC rectifiers, including battery feed
- Two 230 VAC inverters with electronic and manual bypasses
- One 220 VDC main distribution
- One 230 VAC / UPS main distribution
- Fire alarm system
- Intrusion alarm system
- Building services with heating and air conditioning (HVAC and lighting)

Operation and monitoring must be performed by the control system for the switchgears and switchboard sections listed below.

- 22 kV switchgear
- 400 / 230 VAC main distribution with 1 busbar, a coupling, and the 2 feeds listed below
  - Station service transformer 22 / 0.4 kV, 160 kVA
  - 400 VAC emergency power diesel system, 50 kVA

The process I/O requirements are given below include the required reserves.

	DI	DO	AI	PT 100	AO
Auxiliaries	32	8	4		
Low / Medium voltage station service	120	32	16	8	

9.9.1.2 Automation units

One automation unit for auxiliaries with primarily local I/O modules for connecting the auxiliary systems, 230 VAC main distribution and 220 VDC main distribution.

One automation unit for the low/medium voltage station service with primarily remote I/O modules for connecting the 400 VAC main distribution, emergency generator and the 22 kV switchgear (alternatively: combined bay controller and protection devices).

9.9.1.3 Diesel emergency power system controls

The commands Parallel Operating Mode, Emergency Power Mode, Diesel Stop, Unlock (after protective switch is thrown) and Emergency Stop must be made available to the diesel emergency power system.

Using the Parallel Mode command, a parallel mode is initiated; that is, the diesel system can be switched to a live busbar via the corresponding synchronization device, and assigned a power level that can be set by parameters, for the purpose of performing periodic tests.

The emergency power mode is enabled by the Emergency Power Mode command. The diesel emergency power group can be started and connected automatically, if needed. In this case, ensure that only those system areas that are authorized to use emergency power get connected and that all emergency powered drives are switched on in a staggered manner when the power is restored.

9.9.2 Bottom Outlet / Intake Control System

9.9.2.1 General

The functions for the bottom outlet and intake are:

- Establishing and managing operating modes and user interface locations
- Interface (commands and messages) to the hydraulic systems (valves and pressure switches)

The process I/O requirements are given below include the required reserves.

	DI	DO	AI	PT 100	AO
Bottom Outlet / Intake	32	16	8		

9.9.2.2 Automation units

One independent automation unit for the Bottom Outlet / Intake must be installed.

9.10 Lower reservoir intake area Control System

9.10.1 Station Service and Auxiliaries Control System

9.10.1.1 General

The auxiliary and station service systems should, to the extent possible, have independent automation, and are primarily monitored by the super ordinate control system. There are essentially the following systems:

- One 220 VDC main distribution
- Fire alarm system
- Intrusion alarm system
- Building services with heating and air conditioning (HVAC and lighting)

Operation and monitoring must be performed by the control system for the switchgears and switchboard sections listed below.

- 400 / 230 VAC main distribution with 1 busbar

The process I/O requirements are given below include the required reserves.

	DI	DO	AI	PT 100	AO
Auxiliaries / Low voltage station service	112	104	16		

9.10.1.2 Automation units

One automation unit for auxiliaries/low voltage station service with local I/O modules for connecting the auxiliary systems, 230 VAC main distribution, 24 VDC distribution and remote I/O modules for connecting the 400 VAC main distribution.

9.10.2 Bottom Outlet / Intake Control System

9.10.2.1 General

The functions for the bottom outlet and intake are:

- Establishing and managing operating modes and user interface locations
- Interface (commands and messages) to the hydraulic systems (valves and pressure switches)

The process I/O requirements are given below include the required reserves.

	DI	DO	AI	PT 100	AO
Intake	16	8	8		
Bottom Outlet	16	8	8		

9.10.2.2 Automation units

One independent automation unit for the Bottom Outlet and the Intake must be installed.

9.11 <u>Metering</u>

Calibrated 4-quadrant meters with ¼ h average power load profile per quadrant must be used, including communication modules and modem for remote meter reading via an analogue telephone line.

All meters must be wired in enclosures to meter testing terminals (interface to current transformers).

An energy balance for the entire plant is produced in the control system. The meters are connected to the process control system via weighted impulses (floating contacts).

The metering equipment must fulfil the relevant regulations, norms, and standards.

- Two meter, class 0.2, on the 15.8 kV side for capturing gross production of the generators of the unit (one of them dedicated for IECo)
- Two meter, class 0.5, on the 15.8 kV side for the feeds through the station service transformers 1 and 2, for metering internal power consumption
- Two meter, class 0.5, on the 22 kV side for the feeds through the station service transformers 3 and the auxiliary power transformer, for metering internal power consumption
- One meter, class 0.5, on the 22 kV side for the feed through the station service transformer, for metering internal power consumption of the upper reservoir
- One meter, class 0.5, on the 400 V side for the feed through the emergency diesel power system in the operating building, for metering internal power consumption
- One meter, class 0.5, on the 400 V side for the feed through the emergency diesel power system in the upper reservoir, for metering internal power consumption

The billing meters per incoming feeder bay on the 161 kV side of the unit and other meters for internal power consumption of the switchyard operating building are in the scope of the specification for the switchyard.

9.12 Control Center System

9.12.1 General

The following system properties are required for the planned Supervisory Control And Data Acquisition (SCADA) system:

- High-performance system architecture, with distributed intelligence over several processing units (multi-computer system)
- High availability, with high-performance multi-processor hardware with delimited, feedback-free subsystems and hot standby redundancy
- Each computational unit must be equipped with an appropriately high processor performance and memory, in order to ensure deterministic response times even under high loads.
- The complete process state must be available in the working memory of the computer.

- The ability to expand the system later by integrating new system components via standardized bus systems must be provided.
- The system must be secured online and automatically, so that automatic restart with no loss of data can take place in case the system failures.
- In order to simplify maintenance, the system must have extensive diagnostic functions.
- For better data portability, and for coupling to third party systems, the database requires a standard interface in SQL.
- Compatibility and communication between different communication infrastructures (e.g. Office network) and computer systems (web servers) must be possible using standardized protocols and appropriate decoupling via a firewall, etc. according **Israeli cyber security standards**.
- Standard commercial software, such as a word processor (Word) and spreadsheet (Excel), must be integrable in the system environment.

The selected software packages must have high reliability. In addition to process visualization, requirements include recording of process data on the monitor and printer, archiving defined data on portable media, alarm initiation in case of error, and basic processing functions for binary and analogy data. The following additional basic requirements must be met:

- Integrated software concept for providing the above functions with a user-friendly interface, using selection menus and operator guidance via help functions, color and fonts that can be freely generated, records, images, and simple entry or changes to the data model
- Additions and changes can be performed independently by the operator after the system training, and are automatically documented by the system.
- The system must be quantitatively and functionally expandable, while maintaining the tested system environment.
- The system must stand out in terms of scalability. This means that, starting with a small level of expandability, additions such as additional workstations, operator monitors, printers, etc. and redundant servers must be able to be retrofitted.
- A simple, easily understood user interface, largely based on the familiar operating functions in Windows.
- Using standardized interfaces, such as SQL, OPC, etc. external applications must be able to access archive data, online data, and the contents of the alarm and event lists, as needed.

In order to achieve high availability, the SCADA system must be made up of modular program packets. Client-server architecture is assumed.

- SCADA server (process data server, singular or redundant)
- SCADA client (workstation, multiple places in the overall system)
- Engineering tools (support for object orientation when parameterizing)

The client application (workstation) must be able to run on one computer, together with the server. Based on this all-in-one configuration, the system must be able to be expanded to a distributed client/server architecture (communicating via Ethernet TCP/IP). Several clients communicate with the SCADA server or servers.

In the project, the SCADA server must be run in redundant (“hot standby”) mode, in order to meet the available requirements.

A central, object oriented engineering tool must be provided for configuring the parameters of the database of the overall system.

The SCADA server essentially contains:

- SCADA functionality
- Archiving and analysis functions
- Actuate output devices

The SCADA client undertakes the function of displaying the process variables provided by the server. It can be present as multiple instances in the overall system, and the server supplies it with computed values and status of the (currently displayed) process variables. Process information is largely shown using images, curves, lists, and reports.

In order to achieve maximum performance with distributed systems, as much intelligence as possible should be shifted to the clients. The process screen views and data displaying methods should also be stored locally at the client, while the server provides the current state and data of the system.

Up to 4 monitors must be able to be connected to one SCADA client.

The computer hardware and operating system must be qualified and validated to run the SCADA application. Support of the system has to provide:

- Maintenance of all software over a period of at least 10 years after expiration of the warranty

Within the system family used, it must be possible to expand the system as needed at any time, such as by

- Using newly developed devices with new features or as replacements for existing devices.

- Increasing computer performance by using more powerful computers or another processor.
- Increasing the amount of RAM or mass memory to adapt to additional informational scope.

The computers and peripheral devices will be installed in the system room and the control room in the Plant Control Center area.

9.12.2 Server

The SCADA service is the “data processing” component of the system. The information gathered by the automation units are processed, archived, and made available here for output to the display and records.

The interfaces to the process and HMI LAN are specified as follows:

- Ethernet per IEEE 802.3 10/100 MBit/s
- Protocol TCP/IP (Transmission Control Protocol/Internet Protocol)
- Twisted pair Ethernet (RJ45) type cables

The data model of a server must be able to handle at least 30,000 data points.

The remote control interface is implemented via Process LAN. The corresponding driver must be integrated in the control system, and must also be configured there.

To the extent possible, the latest version of database system should be used as the archiving and data management system for all data point definitions and as a long-term archive.

Redundant servers must be used for the Plant Control Center. These are supplied with process data in parallel, have an identical process map, and run their identical internal programs. Command outputs are performed on only one process control server.

If the process control component (PC) fails, the hot stand-by computer (SB) takes over the operational control without loss of data. Operational states are changed automatically in case of an error. All devices (workstations and printers) required for operations are then automatically assigned to the process control computer (PC).

Windows should be used as the operating system.

Both computers in the redundancy set must be equipped with two Ethernet network cards.

The power supply for the two servers must be redundant.

9.12.3 System monitoring

The following internal system monitoring must be performed:

- For the software:
  - Check for program crash
  - Check the reaction time of a program
  - Correct processing of a program
  - Watchdog monitoring of the server
  - Check for data consistency
- For the hardware:
  - Continuous LAN monitoring
  - Periodic monitoring of devices that are not continuously addressed by software
  - Devices are monitored by querying the status indicators with each access.

9.12.4 Backup and data storage

Both server systems and the HMI systems must be equipped with DVD burners.

Process data and project parameter data are saved to a file system, of which additional copies (e.g. on DVD) can be made.

The user interface 1 is preferred for saving process data and project parameter data. This backup must be done automatically every day (after midnight). The last 7 saves (7 days) are retained for each system.

9.12.5 System backup

After the computer has had the operating system and the SCADA software installed, an image of the hard disk must be created (e.g., using Acronis True Image) and saved to the backup medium.

9.12.6 Plant backup

After the screens have been adapted, or adjustments made to the SCADA system, a plant backup must be able to be initiated by an administrator using the appropriate button.

9.12.7 Archive backup

The closed archive from the previous day must be exported to a file system automatically every day. This export directory should preferably be on the backup for user interface 1, from which additional copies to external media can be initiated by the administrator.

9.12.8 Operator stations

PCs that can be installed in the control desk are to be used for the display workstations. As operating system for all workstation computers an actual version of Microsoft Windows should be used, at least Windows 7.

The two operator stations must each be equipped with two 24” TFT monitors, a country-specific keyboard with 12 function keys, and an optical mouse with two buttons and a scroll wheel.

The display systems handle all visualization tasks at the workstation (operator station), such as image display, curve display, process control, etc.

The mobile workstation (notebook with 17” TFT LCD display) must allow access from each switch in the network, and have all the functions of the stationary operator stations. The notebook must have a country-specific keyboard.

The mobile workstation computer should also be able to be used as the engineering and service station, that is, for project parameters and diagnostic activities.

9.12.9 Printer

A network-capable A3 color laser printer (600 dpi resolution) must be used for outputting hard copies of screen displays and trend curves. A second network-capable black and white A4 laser printer (600 dpi resolution) is required for outputting lists and logs.

Both printers must be connected to the HMI LAN via the 10/100BaseT Ethernet interface.

9.12.10 Engineering System

A central, superordinate and object-oriented engineering tool must be provided for configuring the database parameters of the overall system. The same tool that is used for the mobile workstation should be used here as well.

The following basic requirements must be met by the engineering tool:

- The engineering tool is object-oriented, in order to be able to exploit potential savings when engineering data points for the process model and screens.
- The SCADA system and automation units must be maintained with the same tool.
- The actual structure (circuit breaker consists of an “on” command, “off” command, feedback signals, breaker trip, etc.) and the parameters (e.g., running times, alarm processing, visualization) must be treated separately in the object structures. There is a one-to-n relationship between the object structure and the parameter sets.
- Inheritance must be possible for both object structures and parameter sets.

- Mass processing (creation of data points from previously created objects) must be supported by standard user interface technologies, such as drag & drop, copy & paste, multiple selection, etc.

- Display and processing of the database should be possible in both tree and list form. It must be possible to switch between these views without an import/export process.

- All parameters of the data point (visualization and remote control) must be managed in one tool.

- In order to minimize inputs and errors, it must be possible to generate parameters from other parameters using references or formula calculations.

- An import and export interface must be available.

- In addition to pure process data management, it must also be possible to integrate and manage any other desired information.

9.12.11 Communication

The Process LAN driver in the SCADA system communicates with the automation units using all typical system and monitoring mechanisms.

The Process LAN driver captures all status information that is transferred with the process data and makes them available to the post-processing functions via the process map.

9.12.12 Time handling

Time synchronization uses NTP (Network Time Protocol). The real time is set for each computer (SCADA system, touch panel PC, automation unit) by the centrally situated GPS NTP server.

In case of failure of the time impulse, or in case of erroneous time telegrams, the internal time of the component is used. In the computer group in the Control Center System, the internal time of the process control server is used via the clock master.

The free-running precision of the time system, in case of failure of the GPS synchronization source, is < 50 ppm (parts per million, at constant temperature).

The switch between standard and daylight saving time is carried out automatically.

9.12.13 Availability

The goal of generating electricity without interruption, as much as possible, leads to high requirements for availability and reliability of the individual automation units of the control system.

The SCADA system servers work in hot standby mode. The exchange of information between the process control computer PC and the standby computer SB is limited to operator commands (e.g., manually entered values) and system telegrams (e.g., computer monitoring, error handling, startup coordination, etc.). No process data are exchanged between the PC and SB computers.

The SCADA system is no longer available if immediate observation of the plant condition, including commands, is not possible on any of the workstations. This is the case if the following components fail 100%.

- SCADA Server
- Computer network
- Workstation computer

The availability of the SCADA system is expected ≥ 99.94% during the probation period and ≥ 99.94% per year during the warranty period. A maximum of 1 total failure per year is tolerated.

Single errors are detected by the system and do not result in interrupted operations, with appropriate redundancies, by automatically switching between computers.

The availability of the touch panel PCs is expected ≥ 99.80% during the test period and ≥ 99.80 % per year during the warranty period, and up to 3 failures are tolerated.

Subsystems that are not part of the scope of supply of the contractor, but that affect availability, are considered to have 100% availability.

The prescribed availability of ≥ 99.94 % for redundant systems, or ≥ 99.80 % for single systems, applies to all automation units used in process-based control systems.

9.12.14 Normal mode

The system reaction (screen selection time, alarm reaction time, command output time) for the SCADA system and the touch panels in the local control areas are defined as follows.

The screen selection time is defined as the time between the operator command (selecting the function for screen selection) and the moment at which the screen is fully displayed on the monitor.

Alarm reaction time in the control system is defined as the time between the receipt of process information at the process interface (process LAN, serial interface to the automation unit) and representing the process information in a process screen or a list.

The command processing time is defined as the time between the operator command (executing the appropriate function) and forwarding the command to the interface of the process.

The provided system shall be designed according to modern best practice and state of the art design therefore the system reactions times shall be in the range of:

Action	Reaction time
Screen selection time	0.5 seconds
Alarm reaction time	1 second
Command processing time	1 second

9.12.15 Standard failure

The “standard failure” scenario and associated time response is defined in the work statement.

When the computer performance is selected, appropriately high system loads should be considered for the case of surge of messages and their processing in the standard failure case.

9.12.16 System restart and switchover

The reaction times listed below contain the times for the database update in the Control Center System. After a system restart or computer switchover, the system is again completely ready to run.

The provided system shall be designed according to modern best practice and state of the art design therefore the system reactions times shall be in the range of:

Action	Reaction time
Restart after total failure of the SCADA system, up to restoring the process controls, with a display workstation	< 8 minutes
Switchover / hot stand-by	< 5 seconds
Restart after total failure of a touch panel, up to restoration of process control	< 3 minutes

9.12.17 Archiving

Archiving serves to record and store process data and process variables derived there from, which are then available for later post-processing. It must be possible to use export functions for analysis with MS Excel.

The goal of archiving is to capture and compress (average, sum, maximum, and/or minimum) the process data over several levels, together with a flexible and user-friendly editing level that conforms to the system.

Analysis or post-processing of the archive data can be done in the curve display, a protocol generator, and an archive edit window.

Archiving is based on the principle of cascading the archives, that is, the desired process variables are captured and included in a subsequent archive using compression functions. This process should be able to run as often as desired. The compression function is initiated at the end of the archiving cycle. Summation, averaging, minimum, or maximum must be available as the compression functions for each archive process variable, over the archiving cycle.

With a high number of process variables to be archived, several cascades can work in parallel.

9.12.18 Error signalling

The following diagnostic information must be displayed:

- Component failure (watchdog expired)
- Component status for each automation unit
- Diagnostic information about the rest of the system (external fields, communications fields)

All diagnostic information must be displayed, recorded, and archived.

9.12.19 Error detection

In addition to error detection and signalization, all means should be used to indicate precisely to the operator which parts of his processes are affected by the error. This ensure that the operator

- can determine the urgency of clearing the error, and engage service personnel accordingly
- can detect, being cognizant of the process information that is no longer available, whether the process must be continued locally and manually (use of additional personnel).

9.12.20 Human-machine interface (HMI)

The graphical user interface must fully support the typical Windows functions, such as context menus, forms, multiple windows, and multiple screens.

After an object is selected, a right mouse click should be sufficient to display the most important commands that should be available immediately. A mechanism for multiple confirmation layers must be provided for issuing commands.

The typical Windows properties must be supported, so that the size and position can be changed independently of the monitor limits. Properties that are essential for operations in the control room, such as panning, zooming, decluttering, etc. should also be possible.

9.13 Signal List IECo – Powerplant Control System

Following tables list the typical signals needed from IECo of the power plant. And also some commands send from IECo to the power plant control system.

For each generator

Signal / Command Name	**Destination**	**I/O**	**Signal**
Generator circuit breaker on	RTU	DI	
Generator circuit breaker off	RTU	DI	
Generator active power	RTU	AI	4 – 20 mA
Generator reactive power	RTU	AI	4 – 20 mA
Generator voltage L1-L2	RTU	AI	4 – 20 mA
Generator voltage L2-L3	RTU	AI	4 – 20 mA
Generator voltage L3-L1	RTU	AI	4 – 20 mA
Generator active energy MWh	RTU	AI	4 – 20 mA
Generator protection general alarm	RTU	DI	
Generator protection lock out relay trip (86 A)	RTU	DI	
Generator protection lock out relay trip (86 B)	RTU	DI	
Generator U/O voltage protection	RTU	DI	
Generator U/O frequency protection	RTU	DI	
Generator negative sequence protection trip	RTU	DI	
Generator U/f protection trip	RTU	DI	

For the IECo room in the powerhouse

Signal / Command Name	**Destination**	**I/O**	**Signal**
Ambient temperature	RTU	AI	4 – 20 mA
Humidity	RTU	AI	4 – 20 mA

Direct measurements by optical multiplexer (OM) for each generator

Signal / Command Name	**Destination**	**I/O**	**Signal**
Generator active power	OM	AI	4 – 20 mA
Generator reactive power	OM	AI	4 – 20 mA

Load Flow Controller (LFC)

Signal / Command Name	Destination	I/O	Signal
Permissive from the unit means readiness for increasing/decreasing of load from LFC	RTU	DI	
Indication that LFC starts to control the unit	RTU	DI	
Load demand (transmitted from LFC)	RTU	AO	4 – 20 mA
Lower limit of load control	RTU	AI	4 – 20 mA
Upper limit of load control	RTU	AI	4 – 20 mA
Maximum permitted load change rate	RTU	AI	4 – 20 mA
Unit active power	RTU	AI	4 – 20 mA
Target set point of unit as result of LFC demand	RTU	AI	4 – 20 mA
Command LFC to operator	RTU	DO	
Command LFC start	RTU	DO	

9.14 Inspections and Tests

All tests and inspections necessary during or after installation in order to ensure and demonstrate the required operational capability of the delivered item(s), as well as those necessary for this purpose for adjoining deliveries, are fundamentally to be included in the scope of delivery.

Commissioning of the control equipment and devices includes verification of all equipment functions and data point tests to all parts of the control system.

Please also refer to the inspections and tests specified in the General Technical Specifications.

9.15 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

9.15.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

9.15.2 Drawings and Information to be submitted after Commencement Date

The documents in the following chapter are to be supplied to the costumer before erection. This list contains a minimum requirement, if it is understood by the contractor, that more information is necessary, especially when listed in this specification, this has to be delivered additionally.

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Document and drawing directory	Data	
Overview diagram for the control and communication system	Design Drawing	
Control system general design report	Technical Report	
Network and power supply block diagram for all equipment	Design Drawing	
Network drawings with IP configuration	Design Drawing	
Overview drawings showing placement • Control rooms disposition • Overview of system cabling • Detached I/O modules • Interfaces and locations of transfer terminal strips for external systems • etc.	Design Drawing	
Standard operational manuals	Manual	
Data sheets of main components	Data sheet	
Design and disposition drawings	Design Drawing	
Unit protection single-line drawings	Design Drawing	
Unit 1-2 functional and tripping definition (Emergency stop, quick stop, Start / Stop sequences)	Technical Report	
Remote communication interface definition	Technical Report	

Signal lists (including signals to other parts of the contract)	List	
Layout drawings and door views	Design Drawing	
Wiring diagrams	Design Drawing	
Terminal diagrams, connection drawings, wiring lists, cable lists and equipment lists	Design Drawing	
Functional descriptions	Technical Report	
Grounding and lightning protection drawings	Design Drawing	
Assembly drawings	Design Drawing	
Operator manuals, functional descriptions and configuration, descriptions, Logic diagrams	Manual Design Drawing	
Program listings for automated devices and control system	Design Drawing	
PLC functional drawings	Design Drawing	
Parameter lists	List	
Software on data storage media	Data	
Equipment manuals and equipment documents for all modules and systems, including configuration data	Datasheet	
Descriptions of all software modules	Technical Report	
Data point lists	List	
Facility and process screens	Image set	
Test records, test certificates and acceptance records	Technical Report	
Records of commissioning and functional testing at the facility	Technical Report	
Hardware and software test records and documentation	Technical Report	
Fiber optic and network cable measurements	Technical Report	

Confirmation of the implementation of and conformance to regulations and standards	Technical Report	
Cable and conduit routing drawings	Design Drawing	
Facility labeling and marking documentation	Design Drawing	
Maintenance manuals and schedules	Manual	
Calculations, analyses and proofs (short circuit, voltage drop, selectivity, etc.)	Technical Report	
Password directory	Data	

10 PROTECTION SYSTEM

10.1 General Description

The protection system for the PSPP Manara power plant encompass the unit protection, mechanical protection, hydraulic protection and the electrical protection system. The electrical protection system in this specification includes the unit / generator, the 15.8 kV switchgear in the powerhouse, the 22 kV switchgears in the powerhouse and the 22 kV switchgear in the upper reservoir operating building.

10.2 Scope of Supply

10.2.1 Hydraulic Protection

One (1) set of the necessary measuring and control equipment for the hydraulic protection system

10.2.2 Mechanical Protection

One (1) set of the necessary measuring and control equipment for the mechanical protection system

10.2.3 Electrical Protection

Two (2) cubicles for Electrical Generator and Transformer protection

One (1) set of differential protection panels located in the switchyard

One (1) cubicle for protection of the 15.8 kV switchgear and station service transformers in the powerhouse

One (1) cubicle for protection of the 22 kV switchgears and station service transformers in the powerhouse

One (1) cubicle for protection of the 22 kV switchgear and station service transformer in the upper reservoir operating building

One (1) set of fibre optical cables needed for the protection system including lines from switchyard to powerhouse

One (1) set of communication equipment for distributed protection function (e.g. differential protection)

10.3 Unit protection

The task of unit protection is to monitor the unit for unallowable operating conditions, detect malfunctions at an early stage, and safely stop the unit if necessary.

Different types of tripping occur, depending on the hazard incident:

- Quick shutdown 1 (QSDI) trip
- Quick shutdown 2 (QSDII) trip
- Emergency shutdown (ESD) trip
- Unit stop (UST) trip

The protective devices are always armed, but some trip conditions must intentionally be suppressed during start-up sequence to allow start-up to occur. After a protective device trip, the machine controller is blocked. It must always be unblocked by the operator before another start-up process is possible.

All trip command circuits (QSDI, QSDII and ESD) must be powered from 220 VDC.

10.3.1 Emergency shutdown (ESD)

In the event of an emergency shutdown trip, stopping takes place over a wired contact chain.

The objective of emergency shutdown is to reach the de-energized state as directly and quickly as possible and to unload the unit. For this purpose, the generator circuit breaker is tripped directly without delay under load and the emergency shutdown valve is actuated at the same time. Increased turbine speed and associated mechanical stress are accepted in this situation as a calculated risk.

A tripped emergency shutdown is sensed by the Monitoring component. In addition it stops the unit in an orderly manner with the aid of the auxiliary equipment.

10.3.2 Quick shutdown QSDII (with speed increase)

A QSDII quick shutdown is usually triggered by an electrical protection criterion. QSDII directly trips the circuit breaker (block circuit breaker and/or generator circuit breaker and circuit breaker in the station supply circuit) and de-excitation. The quick shutdown is executed by the turbine controller. Tripping is not sequentially controlled, but instead only event-driven.

Unit protection tasks in the event of a QSDII quick shutdown:

- QSDII trip command to turbine controller
- Circuit breaker(s) Off
- De-excitation On
- Orderly stopping of the unit using the auxiliary equipment

10.3.3 Quick shutdown QSDI (without speed increase)

A QSDI quick shutdown is triggered by a mechanical/thermal protection criterion. Unlike ESD or QSDII, in this case it is not necessary to disconnect the unit from the power grid under load. The machine is first unloaded and then disconnected from the grid. The quick shutdown process is controlled and executed exclusively by the unit protection unit.

Unit protection tasks in the event of a QSDI quick shutdown:

- QSDI trip command to turbine controller
- Monitoring of load shedding
- Generator circuit breaker Off (load < 5%)
- De-excitation On
- Orderly stopping of the unit using the auxiliary equipment
- Time monitoring of shutoff

10.3.4 Unit stop

In the case of non-critical protection criteria, it is sufficient to stop the unit in an orderly manner. An orderly stop sequence must be implemented in the Monitoring component for this situation. If the stop command is not executed within a specific time period, the machine protection triggers a quick shutdown (QSDI).

A machine stop triggered by machine protection blocks the machine controller.

10.4 Mechanical protection

Mechanical protection and automatic hazard shutdown shall be implemented in redundant CPU with redundant connection to fieldbus and Process LAN.

If transducers are needed for both mechanical protection and control, they are interfaced via the peripheral devices.

Transducers whose signals are processed by the mechanical protection component for tripping shall be monitored for transducer failure (transducer faults and open circuits). Trip circuits shall also be constantly monitored.

All transducers and measured values necessary for the implementation of the necessary protection functions shall be monitored in the mechanical protection component for proper operation within configured parameter ranges. The protection system protects the unit and the associated transformer against any form of damage by stopping according to the trip scheme. Mechanical protection shall be monitored by a watchdog contact. Failure of mechanical protection causes an emergency shutdown of the unit.

The trip criteria for mechanical protection act directly on the circuit breaker, excitation system, hazard shutdown relay, quick shutdown, and emergency shutdown if appropriate.

The following functions shall be implemented in the Monitoring component:

10.4.1 Alarm system

All external or internal signals indicating an abnormal system state shall be processed in the functional module. The message scope, alarm and visualization on the touch panel of the unit control center (UCP) shall be specified in detail in cooperation with the Owner.

10.4.2 Tripping

The mechanical protection system processes all fault states of the block (unit and transformer) with the exception of electrical faults, which are sensed and processed by the electrical protection system.

Every signal that causes tripping shall be processed automatically in the mechanical protection component, independently of the control component. It causes an alarm as well as the shutdown of the unit according to the type of fault. In addition, a normal stop sequence in the control component is initiated.

The trip programs shall be implemented via a trip matrix in software as part of the safety module. The inputs to the trip matrix are the various trip signals, and the outputs of the trip matrix are fed to the trip relays of the switch components.

The rotation speed limit is supplied to the mechanical protection (monitoring) component and the stop/start controller (control component) by the turbine controller and an independent speed monitoring device.

10.5 Hydraulic protection

The hydraulic protection system is an autonomous CPU of the control system. Signals of the hydraulic protection system are hard wired connected to the control system.

The hydraulic protection system is used for:

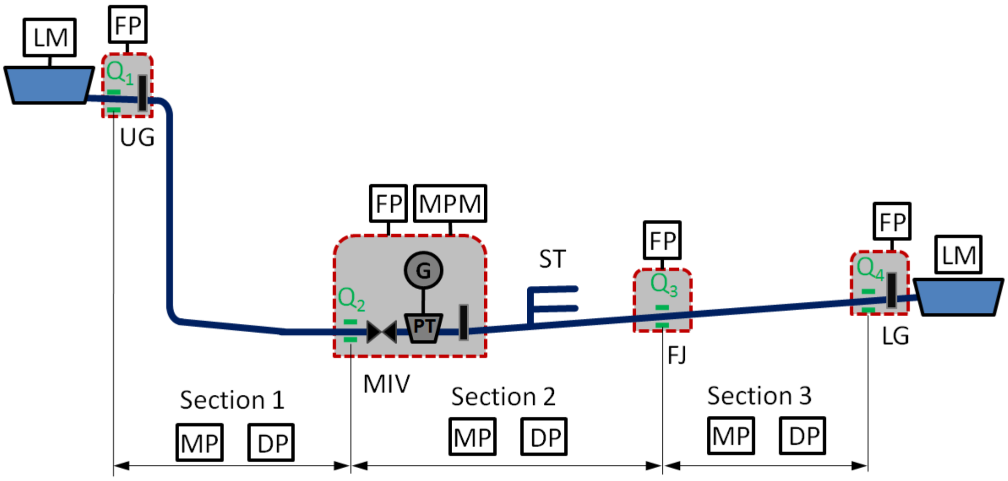
- Monitoring of the maximum permissible engine water flow
- Detection of larger leaks or a pipe break by comparing the incoming and outgoing water flow (hydraulic differential protection)
- Monitoring of the maximum permissible engine water flow
- Pressure monitoring for the machine before the main inlet valve and in the tailwater race

Sensors are installed along the power waterways, used for the control system of the PSPP as well as for the flood protection system of the waterway system. A summary of the sensors installed is shown inTable 10-1. All sensors are installed redundantly.

Parameter	Type	Accuracy
Water level	Pressure sensor	≤ 0.02%
Discharge	Ultrasonic	≤ 1.0%
Pressure	Pressure sensor	≤ 0.5%
Flood protection	Conductive detector	

Table 10-1: Type of Sensors used for the Hydraulic Protection System

The sensors are installed at neuralgic locations along the power watery system. Figure 10-1 shows the principle arrangement of the hydraulic protection system.



FP	Flood protection
MPM	Max. pressure measurement
MP	Maximum protection (Monitoring of max. discharge)
DP	Differential protection (Comparison of inflow and discharge)
LM	Level measurement
MIV	Main inlet valve
UG	Upper reservoir gate shaft
LG	Lower reservoir gate shaft
ST	Surge tank/tunnel
FJ	Flexible joint chamber

Figure 10-1: Hydraulic protection system of the PSPP Manara

Therefore the following measurement is needed:

Discharge sensors:

- Total flow in the pipeline from the upper reservoir
- Flow of unit before the main inlet valve
- Total flow in the pipeline from the lower reservoir
- Flow of unit in the tailwater race

Pressure sensors:

- Total flow in the pipeline
- Unit before the main inlet valve
- Unit in the tailwater race

Water level measurement:

- Upper reservoir
- Surge tank
- Lower reservoir

Flood protection:

- Upper reservoir intake
- Power cavern
- Flexible joint chamber
- Lower reservoir intake

10.6 Electrical protection

10.6.1 Unit / Generator protection

An overview of the Unit Protection System for the PSPP Manara is shown in drawing MANARA/BD/ED/05/003.

Electrical protection of the machine unit encompasses:

- Generator
- Unit transformer
- Power lines up to the switchyards
- Station supply feed

If an electrical protection criterion is tripped, a QSDII quick shutdown is always triggered (with the following exceptions: a rotor short circuit leads to a unit stop, and tripping of overcurrent time protection for the station supply feed affects only the associated circuit breaker).

The signals from the electrical protection system shall be transmitted serially (IEC 60870-5-103 or – IEC 61850 protocol) to the Monitoring component and processed there as hazard messages (no active protection function in the automation unit).

Electrical protection must be divided into two systems.

Each system consists of one or possibly more numerical protection devices with trip logic. Both protection systems must operate independently of each other.

The protective functions must be assigned to the two systems in such a manner that the protective functions support each other as much as possible, and that the electrical protection is maintained by the other system (at a reduced level) if one protection system fails.

The following minimum scope of protective functions must be assigned to the two systems:

System I:

- Minimum / maximum voltage (27 / 59)
- Minimum / maximum frequency (81U/O)
- U/f function (24G)
- Voltage supervision (VTS)
- Reverse Power (32)
- Under excitation (40)
- Under impedance (21)
- Stator earth fault 95% (64S)
- Stator earth fault 100% based on 3rd harmonic (27TN)
- Rotor earth fault (64R)
- Negative phase sequence (NPS) (46)
- Inadvertent protection (27, 50)
- Differential protection for Generators and Transformers (87)
- Thermal overload (49T)
- Transformer saturation (24T)
- Starpoint overcurrent (51TN)
- Startup earth fault (59SN)
- Buchholz, Oil temperature (95)
- Breaker Failure (50BF)

System II:

- Minimum impedance (21)
- Reverse power (32)
- Excitation loss (40)
- Unbalanced load (46)
- Thermal Overload (49L)
- Unit and GIL differential protection (87)
- Momentary overcurrent, inverse overcurrent (50 / 51)
- Overvoltage (59)
- Over and under frequency (81)
- U/f function (24)
- Stator earth fault 95% (64S)
- Interturn fault (51W)
- Breaker failure (50BF)
- 161 kV earth fault and restricted earth fault (59N, 51REF)

This distribution of protective functions over the two systems can change, depending on the devices.

For differential protection the panels located in the switchyard should be provided to the switchyard contractor for their installation.

If the libraries of the protective devices in the proposal include other functions beyond the minimum scope, then they must also be activated and configured at no additional cost to the Owner. Protective functions that exceed the minimum scope should be documented in the proposal.

10.6.2 22 / 15.8 kV distribution protection

The requirements which determined the selection of particular protection chosen are:

- to afford adequate protection at all times
- to maintain maximum flexibility
- to locate, and in instance of short circuit, isolate the faulted section with the least disruption to the overall system

- to provide an easily maintained and uncomplicated system for satisfactory time grading

Protection types for 22 / 15.8 kV distribution

- Differential pilot wire protection on each interconnection cable circuit
- Directional overload protection on each interconnecting feeder circuit
- Directional earth fault indication on each interconnecting feeder circuit
- Winding temperature alarm and trip
- Undervoltage protection

The following minimum scope of protective functions must be assigned to the systems:

- Momentary overcurrent, inverse overcurrent (50 / 51)
- Breaker failure (50BF)
- Unbalanced load (46)
- Thermal Overload (49)
- Directional earth fault (67N)
- Differential protection for Transformers (87T)
- Busbar protection (87B)
- Undervoltage (27)

10.7 Inspections and Tests

The inspections and tests are specified in the General Technical Specifications.

10.8 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

10.9 Documentation

10.9.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

10.9.2 Drawings and Information to be submitted after Commencement Date

The documents in the following chapter are to be supplied to the costumer before erection. This list contains a minimum requirement, if it is understood by the contractor, that more information is necessary, especially when listed in this specification, this has to be delivered additionally.

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Tripping matrix	Design Drawing	
Logic diagrams	Design Drawing	
Settings	Technical Report	
Phase and vector diagram	Design Drawing	

11 POWER- CONTROL CABELS AND CABLE SUPPORT SYSTEMS

11.1 General Description

This section of specifications covers the requirements for the supply and laying of all medium, low voltage and control cables related to the station services and control & monitoring systems of the Manara project. The fiber optical cables for the control system are specified under chapter 9.3.2.1 of this specification.

11.2 Scope of Supply

All 22 kV MV, 15.8 kV MV, LV and control cables and cable supporting systems (ladders, trays, pipes, etc.) inside the powerhouse, operating building, main access tunnel, upper reservoir operating building, upper and lower reservoir bottom outlet, upper and lower reservoir intake, surge tank, dewatering near the flexible joint, as well as cable links between these areas including cable shafts, which will be constructed by the Civil Work Group.

All 22 kV cabling for the upper reservoir operating building station services from the corresponding grid connection point to the switchgear.

All 22 kV MV, 400 VAC, 220 VDC, 230 VAC UPS cabling from the corresponding connection point in the switchyard operating building to the operating building, main access tunnel and to the powerhouse.

All cables to the load centers and main distribution boards of the lighting, telephone, clock and security system. The supply and installation of cables related to the telephone systems, clock system, and cabling from the sub distribution boards to the lighting panels and to consumers will be done by the respective Contractor.

All cables for measuring, protection and control from the instrument transformer terminals to the particular control cubicles including the cables to the unit feeder in the 161 kV switchyard.

The work involves mainly:

- Determination of accurate cable routes on the basis of electrical diagrams.
- Determination of the cableways.
- Establishing of a logical numbering system for the cable numbers. For different types of cables and components a range of numbers should be reserved of enough free numbers of additional installation.
- Unless otherwise stipulated: Determination of cable dimensions taking all necessary reduction factors into account.
- Preparing of cable diagrams, layout plans and cable lists.
- Preparing drawings for the installation of cable supports and trays.

- Submission of a list of material for cables supports, fixing pieces, a.s.o.
- Submission of a detailed program showing particularly:

Preliminary works, supply dates, dates for the laying work and commissioning, matched with work schedules of other contractors

- Supply and lying of cables.
- Supply and installation of cable supports.
- Supply and laying of all tags and labels necessary for the identification of the cables.
- Providing all tools and apparatus for cable testing.
- Transportation and handling up to the working site.

The Contractor shall consider enough spare capability of trays, fixtures and cableways supplied under this Contract.

In addition to the "General Technical Specifications" specified in section 1 has to be fulfilled:

- All cables are to be in one-piece length, without any intermediate junction boxes.
- All cables and tests covered with this specification shall be in accordance with the applicable national and international standards
- All power and control cables running between buildings shall be provided with metal armouring.

Especially the requirements regarding environmental temperatures and laying type have to be taken into account when choosing cable cross section.

All cabling has to be done in cable trays, cable ladders, vertical cable ladders and near sensors and actors in metallic protection pipes.

11.3 Standards

IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV
IEC 61537	Cable management - Cable tray systems and cable ladder systems
IEC 60364	Low voltage electrical installations

11.4 Technical Characteristics

11.4.1 30 kV Medium Voltage Power Cables

For the connection of the 22 kV switchgear, switchgear equipment, station service transformers in the powerhouse, upper reservoir operating building 30 kV cables are used with the following characteristics.

Single phase cables, circular stranded copper conductor, semiconducting compound, insulation of cross linked polyethylene (XLPE), screen of semiconducting compound, semiconducting swellable tape, screen of copper wires and copper tape, separation tape, PE sheath, UV protected

For indoor, outdoor, ground in water and in cable ducts; fixed installation.

The main characteristics are summarized in the table below:

Type	N2XS(F)2Y
Rated voltage	18 / 30 kV
Standards	IEC 60502-2 DIN VDE 0276 part 620
Maximum operating voltage	36 kV
Test voltage	63 kV, 5 min
Conductor material	Copper
Conductor type	Circular stranded
Outer Sheath	PE
Insulation	XLPE leed free halogen free
Longitudinally watertight	
Minimum operating temperature	-20 °C
Maximum conductor operating temperature	90 °C
Maximum short circuit temperature (max. 5 s)	250 °C
Maximum short time current density (1 s)	143 A/mm²

11.4.2 20 kV Medium Voltage Power Cables

For the connection of the 15.8 kV switchgear, switchgear equipment, station service transformers in the powerhouse 20 kV cables are used with the following characteristics.

Single phase cables, circular stranded copper conductor, semiconducting compound, insulation of cross linked polyethylene (XLPE), screen of semiconducting compound, semiconducting swellable tape, screen of copper wires and copper tape, separation tape, PE sheath, UV protected

For indoor, outdoor, ground in water and in cable ducts; fixed installation.

The main characteristics are summarized in the table below:

Type	N2XS(F)2Y
Rated voltage	12 / 20 kV
Standards	IEC 60502-2 DIN VDE 0276 part 620
Maximum operating voltage	24 kV
Test voltage	42 kV, 5 min
Conductor material	Copper
Conductor type	Circular stranded
Outer Sheath	PE
Insulation	XLPE leed free halogen free
Longitudinally watertight	
Minimum operating temperature	-20 °C
Maximum conductor operating temperature	90 °C
Maximum short circuit temperature (max. 5 s)	250 °C
Maximum short time current density (1 s)	143 A/mm²

11.4.3 Low Voltage Power Cables

Solid or stranded copper conductors, cross linked polyethylene, with rated cross-section 1.5, 2.5, 4, 6, 10 or 16 mm², up to 240 mm² with black cross-linked polymer compound suitable for all outdoor cabling. All power cables shall be dimensioned to stay below a 3 % voltage drop at nominal operating current. Current rating is based on DIN VDE 0295.

The main characteristics are summarized in the table below:

Type	N2XH
Rated voltage	0.6 / 1 kV

Standards	DIN VDE 0276-604
Self-extinguishing and flame retardant	IEC 60332-1-2
UV resistant	
Maximum operating voltage	1.2 kV
Test voltage	4 kV
Conductor material	Copper
Conductor type	Ciruclar solid or circular stranded
Outer Sheath	Cross linked polyethylene
Insulation	Cross linked polymer
Minimum operating temperature	-30 °C
Maximum conductor operating temperature	90 °C
Maximum short circuit temperature (max. 5 s)	250 °C
Maximum short time current density (1 s)	143 A/mm²

11.4.4 Low Voltage Control Cables

Solid or stranded copper conductors, cross linked polyethylene, with rated cross-section 1.5, 2.5, 4, 6, 10 or 16 mm², up to 240 mm² with black cross-linked polymer compound suitable for all outdoor cabling of type N2XCH.

11.4.5 Fire Resistant Cables

Stranded copper conductors, halogen-free polymer (HXI 1) insulation, and rated cross-section 1.5, 2.5, 4 or 16 mm², up to 150 mm², with orange outer sheath of halogen-free polymer (HM 4), with 90 minutes functional integrity and 180 min insulation integrity, suitable for indoor and outdoor cabling.

The main characteristics are summarized in the table below:

Type	NHXH E90
Rated voltage	0.6 / 1 kV
Standards	DIN VDE 0266 DIN VDE 0276-604 DIN EN 60228 HD 308 S2
Flame retardant	VDE 0482-266-2-4 IEC 60332-3-24 (cat. C)

Fire resistance (insulation integrity)	FE 180 EN 50200 EN 50362
Functional integrity	E 90
Maximum operating voltage	1.2 kV
Test voltage	4 kV
Conductor material	Copper
Conductor type	Ciruclar solid or circular stranded
Outer Sheath	Halogen-free polymer (HM 4)
Insulation	Halogen-free polymer (HXI 1)
Minimum operating temperature	-5 °C
Maximum conductor operating temperature	90 °C
Maximum short circuit temperature (max. 5 s)	250 °C
Maximum short time current density (1 s)	143 A/mm²

11.4.6 Cable Trays, -Ladders

The cable trays, horizontal and vertical cable ladders include all necessary form parts like bends (45° and 90°), tees, cross-over, straight and angle connectors, corner connectors and accessories like joint plates, bottom end plates, mounting plates, edge protection strips.

Also included is the complete mounting system like ceil and wall supports, head plates, support brackets, fastening, end caps.

Bends tees and cross-over shall be installed as shape parts with such a radius that the allowed bending radius of the cables is kept.

All trimmed edges have to be de-flashed, galvanized and the edges are protected by strips. Trimmed edge of mounting material shall be equipped with end caps in signal color.

Cable trays and ladders are to be pre-fabricated at plant. No welding or cutting works are to be done on site. The contractor shall submit detailed cable tray drawing that include markings for each piece of ladder used. All ladder units are to be of manufacturer standard units.

Each tray and ladder shall include a 16 mm² bare copper wire running the full length of the ladder for grounding continuity.

Cable trays and ladders shall be of "heavy" type with inside depth of 100mm.

Cable ladders for fire safety equipment shall be E90 ratted acc. to DIN 4102 part 12

11.4.7 Metallic Protection Pipes

Included is the full mounting and fastening material like Aluminium connecting sleeves, surround clamp, plastic terminal sleeves. The holder must not be executed as a clamping bracket.

Supply and laying in part lengths.

Floor, wall or ceiling mounting.

Diameter and support with as required.

11.4.8 Anchor Rails

Included is the full mounting and fastening material.

Supply and laying in part lengths.

Floor, wall or ceiling mounting.

Support with as required.

All trimmed edges have to be de-flashed and galvanized

11.4.9 Cable Routes

The Contractor shall determine the cable routes for cable installation by using cable trays, trenches and underfloor ways, etc. and indicate this on appropriate drawings.

By designing the cable routes the following principles are to be considered:

- Gathering of cables of the same voltage level.
- Simplicity and clarity of cable routes enabling the shortest possible lengths.

It shall be avoided:

- The parallel routing of power and control cables.
- The parallel routing of high, medium and low voltage cables.
- Laying of cable in spots where they can be exposed to incidental damage due to handling, erection, maintenance works, liquids, exhaust gases, etc.

- Cables shall be neatly arranged in order to make any cable easily traceable along the whole route.

11.4.10 Laying of Cables

The type of laying and fixing of cables shall be chosen according to the following principles:

- Wherever possible, cables shall be laid on cable racks or cable-trays attached to the ceiling, to the walls or to the walls inside the vertical cable shafts
- All cable routes for emergency load must be separated
- Where the quantity of cable does not justify the installation of a cable-rack or cable-tray, the cable shall be pulled through cable-conduits fixed to the ceiling or wall
- False floors are only provided in the rooms shown in the civil layout drawings, additionally needed false floors have to be supplied by the Contractor.
- Short connections can be pulled through conduits buried in the floors.
- In the vertical routes cable shaft, etc., the cables shall be fixed to the supporting structure with sleeves.
- The cable supporting structures are to be attached to the walls by means of special screws. There will be no auxiliary steel profiles available in the concrete building structures.
- Connectors shall be provided for all entrances of cable in boxes, junction boxes, panel boards, aso.
- The above description is of general character and does not include special cases where specially adapted supports are to be used.
- Cables shall not be buried or laid directly in ground.

11.4.11 Fire protection and fireproof bulkheads

After completion of cable installation, all cable openings in firewalls shall be sealed by certified fireproof bulkheads acc. chapter fire protection, fire-fighting and fire detection system.

This also applies to openings for access to switchgear modules and electrical cabinets on concrete floors, transitions of human-accessible cable ducts, vertical risers, etc. All cables, wiring, electrical distribution units, etc. in corridors, hallways and staircases shall be equipped with suitable fire protection, such as fire-resistant installation ducts or fire-resistant cladding.

Particular care must be given to sealing room bulkheads to ensure that they are impervious to fire, smoke, water and pressure.

11.4.12 Connection of Cables and Identification

- Cable and wire shall be properly stripped; cable jacket overall shall be left as close as possible to the connection.
- The copper sheathing or armour of the cable shall be earthed.
- High and medium voltage cables shall be provided with a cable-sealing end.
- Low-voltage power and control cable connections shall be made either on terminals provided with cleats or by means of terminal plugs.
- All cable ends and connections shall be identified as follows:
- Tags and labels shall identify cable ends
- A plastic sleeve shall identify connections
- Tag and sleeve types as well as identifying codes (color and writing) shall be submitted to the Owner for approval.
- The cable designations shall be in accordance with IEC Standards.

11.5 Inspections and Tests

The inspections and tests are specified in the General Technical Specifications. This tests shall also apply for the MV cables.

11.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

11.7 Documentation

11.7.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

11.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Labelling system	Technical Report	6
Cable Data sheets	Technical Report	6
Cable routing	Design Drawing	8
Laying schedule including cable channels, cable support systems in the civil drawings (ground view and cross sections) and also in a 3D model	Design Drawing	8
Detailed cable laying lists in tabular form incl. cable numbers, cable types, lengths, source and target labels number of occupied and free wires	Design Drawing	8
Operation instruction and maintenance handbooks	Technical Report	15
Electrical calculations and characteristics	Technical Report	8

12 HIGH VOLTAGE CABLE SYSTEM

12.1 General Description

The connection from the unit transformer in the power cavern to the 161 kV air isolated switchyard outside shall be made by 161 kV high voltage cable system.

A cable system comprises of three single phase XLPE 161 kV high voltage cables.

12.2 Scope of Supply

The services shall cover the design, engineering, manufacturing, tests, delivery, installation and commissioning.

It is the Contractor's responsibility to ensure that the proposed cable system is fitting to required transmission capacity and cable laying conditions.

The Contractor has to submit calculations of heat dissipation and current rating of the cable, using CYMACAP or other approved calculation software in order to define the accurate section of the cable.

Basis of the calculation is the cross section main access tunnel, cable trenches/trays in the power cavern and outside towards the switchyard.

All cable support structures and cable fixing accessories shall be part of the scope of supply.

12.3 Standards

IEC 60840	Power cables with extruded insulation and their accessories for rated voltage above 30 kV (Um=36 kV) up to 150 kV (Um=170 kV). Test methods and requirements.
HD 632	Power cables with extruded insulation and their accessories for rated voltage above 36 kV (Um=42 kV) up to 150 kV (Um=170 kV). Part 1- General test requirements

12.4 161 kV high voltage cable system

12.4.1 General

The 161 kV high voltage switchyard area is located near to the portal of the main access tunnel. For electrical grid connection one switchyard bay is foreseen.

The cable system start at the cable outdoor termination in the switchyard bay and it will be led in concreted cable channel up to the portal of the main access tunnel. In the cable shaft building the cable system is changing to the upper section of the main access tunnel. The cable system will be located on appropriate cable support structures above the escape corridor in an open area.

In the power cavern the cable system is going in cable corridors and cable shafts up to the transformer room.

The transformer shall be connected by pluggable cable terminations.

The overall length of one system will be estimated by 1600 m.

IECo approval are required for the 161 kV cables and the outdoor and indoor cable terminations.

12.4.2 Laying conditions

Ambient air temperature in main access tunnel	35 °C
(without heat dissipation of the two cable systems)	
Ground temperature	20 °C

12.4.3 XLPE cable

The high voltage single core cable is UV-resistant and halogen-free, longitudinal and transverse watertight, and consist of the parts, conductor, VPE insulation, copper screen and PE sheath.

<u>Technical data:</u>

Number of cable systems	1
Transmission capacity	260 MVA
Normal system voltage	161 kV
Highest voltage of equipment	170 kV
Minimum system voltage	155 kV
Power frequency withstand voltage	325 kV
Lighting impulse 1,2/50 μs	750 kV
Nominal current (at normal voltage)	932 A
Nominal current (at minimum voltage)	968 A
Conductor	approx. Copper 1200 mm² [7]
Cross section copper screen	150 mm2
Maximum conductor temperature	80 °C (at maximum load)

[7] Final value for cross section and conductor material has to be determined by the Contractor based on cable rating and heat dissipation calculation and in respect of installation costs.

Rated short circuit	(3 phase) 50 kA rms 1 s
Rated short circuit	(1 ph earth) 25 kA rms (expected)
Length of system	1600 m
Type	single core cable
Outer sheath	Halogen free flame retardant layer
Temperature monitoring	optical fibres within stainless steel tubes included in the metallic screen or external fibre optic cable outside

12.4.4 Grounding and bonding

For additional grounding a copper rope of 120 mm² shall be laid in parallel for additional grounding connection between power cavern and switchyard and grounding measures of the steel support structures.

Based on the cable design calculation of the cable supplier the system shall be executed either both cable screen ends grounded (both ends bounding), one side grounded with voltage limiter on the other end (single point bounding), or cross bounding connection to be applied.

Therefor adequate cable link boxes with/without surge voltage limiter and earthing connection shall be provided at the end and on each joint connection.

12.4.5 Outdoor cable termination

The outdoor terminations shall be installed on to steel support structures at the 161 kV switchyard area. The insulator shall be of composite or with porcelain type.

The composite insulator is made of fibreglass-reinforced plastic support tubing with integrally cast sheds of high-grade silicone rubber.

Field control by means of a push-on stress cone made of silicone rubber that also seals the base of the termination, filled with a synthetic insulating liquid.

Insulated installation with special cast-resin post insulators provides the necessary potential isolation between the termination’s base plate and the earthed supporting structure during sheath testing.

Delivery and installation of steel support structure for the outdoor cable termination is not part of this scope of supply. The steel support structure shall be provided acc. section IX - Particular Switchyard / Control Building IEC Specifications.

The fixing of the termination on to the steel support structure shall be part of the supply.

12.4.6 Pluggable cable termination

The pluggable cable terminations shall connect the XLPE cable with the main transformer unit (oil transformer enclosure).

The terminations consists of connector unit, epoxy resin insulator, silicone rubber stress cone, inlet with inner spring assembly, screen connection, cable clamp and support.

The fixing of the termination on to the transformer, delivery and installation of steel support structures, and all connection works shall be part of the supply.

12.4.7 Cable joints

Due to the cable length of approx. 1600 m the XLPE cable system might be divided in several segments. For connecting those segments cable joints shall be provided.

The joints shall be completely maintenance-free, without gaseous or liquid constituents and is built up as one unit of silicone-rubber joint with integrated metallic water barrier, corrosion protection with one or more heat shrinkable tubing.

Straight-through joints with through connections of the screen or sectionalising joints with potential insulation of the cable screen at both sides of the joint can be used. Insulating joints are designed for cross-bonding of the cable screen or for applications with single bonded cable screens.

The fixing of the joints, delivery and installation of steel support structures, and all connection works shall be part of the supply.

12.4.8 Temperature monitoring system

Due to varying ambient temperature along the cable way a permanent monitoring of the cable system shall be applied.

The monitoring system is using DTS technology (distributed temperature sensing) with fibre optic cable in cooperated in metal tube in the high voltage sheath or shall be laid outside on the high voltage cable.

The DTS system shall be fully self-controlled and widely maintenance free. The DTS system shall have programmable zones with multiple alarm parameters, indicating temperature level in or outside of set point. System status, pre-alarm, alarm and fiber break shall also be reported to the power plant SCADA system.

A simplified monitoring system shall allow the continuous monitoring of the sheath temperature. In combination with interface to SCADA visualization software the user is aware of the current thermal condition and the ampacity of the cable system.

The monitoring system consist of optical fibre cable, data units for collecting the cable condition data, computer server with simplified analyse/modelling/storing software with connection to the power plant SCADA system.

Depending on the chosen cable arrangement (flat or trefoil formation) the supplier can propose DTS system by using external fibre optic cable which is located beside/on the top of the high voltage cable system.

12.4.9 Installation and support structures

As per result of the cable design calculation and cable heat dissipation calculation the final arrangement (trefoil or flat formation) at the proposed location shall be defined.

All cables shall be protected against surges, earth faults and over currents, and over temperature. The cable system shall be arranged minimising the electromagnetic influence.

For short circuit proof installation of three single core XLPE insulated cables into a trefoil or flat formation adequate bundling tapes or fixing clamps shall be used. The number of fixing points shall be determined by short circuit calculation.

To limit the fire load in the main access tunnel the cable systems shall be provided halogen free flame retardant.

Delivery and installation of steel support structure, the fixing of all equipment, and all electrical connection works shall be part of the supply. Delivery and installation of steel support structure for the outdoor cable termination is not part of this scope of supply.

After installation the whole cable system has to be tested by measuring cable data.

In addition, a high voltage and partial discharge test on site after completing the installation shall be executed.

12.5 Inspections and Tests

The test procedure shall in accordance to IEC 60840. The cable supplier shall provide typical test program for client´s approval, which include routine tests, sample test, type test program and electrical tests after installation.

Factory Tests

Each cable system and its related equipment shall be subjected to acceptance tests, to be performed at the suppliers’ workshop in order to prove conformity with the guaranteed and other key design data.

Field tests

After final installation at site the cable system including terminations shall undergo a test program according to the manufacturer's practice, (test program is subject to the approval of the Owner.)

At least the following test shall be performed:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement of the electrical installations
- Function test of monitoring system
- DC voltage test of the oversheath
- AC voltage test of the insulation and partial discharge measurement by mobile test truck or mobile high voltage transformer

12.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

12.7 Documentation

12.7.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I, following additional particular documentation shall be provided:

- Cable sizing and thermal calculation

12.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3

Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Spare part list	Technical Report	15
Calculations and characteristics	Technical Report	10
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	1 month before commissioning

12.8 Optional Design

The system supplier shall review, check and prepare a separate price item for the proposal for below defined optional design.

12.8.1 Unit transformers – 161 kV Earthing and disconnector combination

To have an additional earthing location at the unit transformer within the power house the supplier is requested to provide an economical design for a earthing and disconnetor switch combination on the 161 kV high voltage side in the transformer cavern. With the current design the cable system and unit transformer will be earthed by remote earthing switch of the high voltage switchyard.

The scope of supply shall include all kinds of support structures and accessories.

Following known alternative technical solution could be executed.

a) The earthing and disconnector switch can be designed as air insulated arrangement mounted on the inner wall of the transformer cavern. Instead of the pluggable cable terminals dry or flexible outdoor terminations (e.g. Pfisterer) shall be used, which can be mounted headlong to the ground or horizontally. The 161 kV cable plugs have to be changed to transformer bushings. The electrical short connection shall be done by Aluminium ropes or bus bar.

b) The earthing and disconnector switch can be designed by a gas-isolated transformer connection unit including the pluggable cable terminations.

c) Other suppliers solution

In best case the current room dimensions can be kept. In case the transformer cavern will not be of sufficient size the additional space shall be mentioned in the proposal and shall be as small as possible.

13 GROUNDING AND LIGHTING PROTECTION

13.1 General Description

This specification shall essentially comprise the indoor and outdoor grounding and lightning protection systems appertaining to the power plant facilities.

13.2 Scope of Supply

It is the Contractor's responsibility to ensure that the proposed grounding system is fit for its intended purpose for a hydropower generating facility and he shall coordinate his design and supply of equipment and material with the other Contractors (civil, electromechanical works) such that the overall grounding system meets the required design principles as well as the permissible step and touch voltages during fault conditions as per the DIN VDE 0141 and /or IEEE-Std. 80 standards. The grounding system method has also to comply to local electrical standards.

In addition to the grounding system, a lightning protection system shall be designed and provided for all structures. All structures above ground level shall be included in the design. The design shall be in accordance with IEC 62305.

Following areas shall be covered:

- Upper- and lower reservoir area (operation, intake and bottom outlet buildings, dam access road)
- Power water way (at dedicated entrance locations, such like mucking tunnel, surge tank, flexible joint)
- Tunnels (main, flexible joint, surge tank, mucking tunnel, portal building)
- Cable channel in- and outdoor area
- Power cavern
- Control building including outer area

The Contractor shall make ground conductivity measurements at representative point in the cavern, access tunnel, reservoirs and control building area using approved methods.

The work shall cover the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance and control, shop testing, delivery at site, site storage and preservation, testing, handing to Owner of the grounding and lightning system as per the specifications hereunder, complete with all auxiliaries and warranting a trouble free safe operation of the installation.

13.3 Standards

IEC 62305	Protection against lightning
EN 62305	
EN 50522:2010	Earthing of power installations exceeding 1 kV a.c.
IEC 60479-1:1994	Effects of current on human beings and livestock
DIN VDE 0141:2000	Erdungen für spezielle Starkstromanlagen mit Nennspannungen über 1 kV
DIN VDE 0151:1986	Werkstoffe und Mindestmaße von Erdern bezüglich der Korrosion
ANSI/IEEE Std. 80:2000 or 2013	Guide for Safety in AC Substation Grounding
ANSI/IEEE Std. 665-1995	Guide for Generating Station Grounding

According to applicable IEC standards

According to national standards

13.4 Grounding system

13.4.1 General

The design and construction shall be of a well-established system to provide robustness and long-life operation. The erection and manufacturing shall follow the relevant IEC standards.

Therefore one complete, interconnected grounding system shall be provided between power cavern, access tunnel, upper- and lower reservoir and the 161 kV switchyard. Grounding connections shall be laid to the following equipment:

- Gates, valves, intake- outlet structures
- Dedicated entrance locations of power water ways (mucking tunnel, surge tank, flexible joint)
- Stair handrails and doors, metallic cable conduits and trays, metallic piping system
- Switchboards and panels
- Outdoor poles, towers and steel support structures
- Crane rails
- All other electrical, mechanical and hydraulic steel structure components.

The grounding systems shall comprise separate ground meshes for every major structure, such as the cavern, access tunnel, reservoirs, etc. to provide low resistance grounding. The grounding system consists of the following parts:

- grounding mesh below all floors of buildings (cavern, operation and control building)
- grounding mesh in main access tunnel
- grounding of intakes, dam areas and bottom outlets
- redundant interconnection between these areas
- connection of all metal structures to the grounding mesh
- conductors to lower resistivity, buried in the reservoir bed

In case of high resistance the grounding mesh should be laid into the cavern foundation to achieve lower grounding resistance. In this case connections between the copper grounding conductors and the reinforcement of concrete have to be absolutely avoided.

All grounding conductors of subgrade grounding system shall be thermo-welded to metals of different type. All copper conductors of the surface grounding system shall be joined using cable lugs, bolts nuts and shims.

The various grounding systems of the major structures shall be connected together only in the ground terminal boxes. It shall be possible to measure the earth resistance of each sub-system individually.

The lightning protection and grounding system shall be connected at various points at ground level to the main grounding grid. These connections shall be separable for measuring purposes.

13.4.2 Earthing scheme

The following scheme for grounding the equipment neutrals shall apply:

- 161 kV system — Solidly and effectively grounded
- 15.8 kV system — by means of a transformer or resistor grounded
- 400 V system — Solidly grounded

The following fault levels shall be taken into consideration when designing the system:

- 161 kV levels — symmetric value — 50 kA / 1 s
- 161 kV levels — ground circuit fault — 25 kA / 1 s (assumed)
- 15.8 kV levels — symmetric value — 72 kA / 124 kA* /1 s

- 0.4 kV levels, symmetric value 77 kA / 1 s

* value at branch

The results of the ground resistivity measurements shall be taken into account in designing the systems and avoid lengthy tests and modifications once the system has been built to achieve the required ground resistance of the system.

13.4.3 Building grounding system

All floors shall have a grounding mesh beneath to keep step voltages low. The horizontal ground grid for each of the above floors shall be embedded in approximately 15 cm of concrete.

All floors shall be vertically interconnected and embedded in the walls to form a 3D earthing cage.

The grounding system shall be connected with the other grounding systems via at least two independent copper conductors.

Buried ground conductors shall be laid around all buildings, all exterior tanks, fences and other large metallic objects. The distance of these conductors from the building walls or the contours of the protected object shall be about 150-200 cm and placed at a depth of about 100 cm below finished level. These buried ground electrodes shall be properly connected with the respective building or object grounding systems at least at 2 points or every 20m.

13.4.4 Reservoir area grounding system

Appropriate grounding shall be laid at all of this locations, intake structure, bottom outlet, valve chamber, outdoor lighting system, cable trenches and all other electrical, mechanical and hydraulic steel structure components.

All sub-systems shall be interconnected between themselves and with the other systems by means of earth wires.

Connections to the grounding system of apparatus and equipment mounted on the dam area are also included in this contract.

13.4.5 Potential equalisation network

All electrically conductive construction parts shall be connected to the potential equalisation network. Outdoor equipment has to be treated in the same way as indoor equipment.

The potential equalisation within rooms has to be ensured via connection of relevant grounding busbars and equipment from various sides. For this purpose a copper potential equalisation busbar with a cross section of at least 5x40mm² has to be provided, which is also included in scope of this specification. The proper connection to the busbar is in the scope of the respective equipment supplier. All incoming services (lines) have to be connected to this busbar, when entering the project area.

All fixed grounding points have to be of copper. All conductive parts are connected to this points via the potential equalisation busbar and therefore serve as grounding, potential equalisation and protection zone concept parts in one. Per room, at least 2 such points shall be foreseen. Their location shall be such, that no connected part is further than 10m away to ensure short connections to the main mesh.

For fixed equipment and conductive facilities a direct connection to the grounding mesh is suggested. This is done through grounding connectors with a minimum area of 16 mm².

For grounding conductors with insulation, only yellow-green colour is permitted.

13.4.6 Equipment grounding

All neutral points of electric machinery and other system points as indicated on the diagrams and drawings or as required by the Standards shall be connected to ground (via the potential equalisation busbar) in the shortest possible way, in a safe and robust manner, to give high conductivity and the lowest possible zero sequence impedance. These connections shall be visible and clearly marked. Minimum conductor area for these connections is 16 mm², the final area is determined through IEC 60949. Contact corrosion has to be avoided.

For larger equipment, such as draft tube, penstock, main transformer, switchgears, HV equipment, etc. at least two such connection points shall be provided.

The Contractor shall connect all of the equipment and metalwork installed by the civil contractor.

13.4.7 Materials

Conductors used in meshes in the cavern shall be 120 mm² cross-section area bare stranded copper cable. The grounding mesh in the cavern and its risers shall also be of the same 120 mm² conductor size. Sharp bends have to be avoided as far as possible.

Copper conductors shall be medium-hard bare copper and its resistivity shall not exceed 0.017837 ohms-mm² per meter at 20°C in accordance with the International Annealed Copper Standard.

13.5 Lightning Protection

13.5.1 General

In order to protect the outdoor facilities of upper- and lower reservoirs, control and portal buildings against lightning, Faraday type lightning protection system in conformity with IEC 62305 standard, shall be provided.

The Contractor shall strictly observe the local safety regulations and/or other approved regulations, supply all protective equipment required for minimizing any potential damage to project buildings, structures and tanks by lightning.

After a risk analysis protection zones shall be applied.

The lightning protection shall be designed according to the rolling sphere method.

The lightning protection system for buildings is done via conductive meshes on the roof and rods on the edges. Any objects pointing out of this mesh have to be protected separately.

The necessary protection of free areas shall be done with lightning protection towers. The earthing wires of overheadlines can be taken into consideration.

Down droppers of the same size and material as the roof lightning grid shall be included regularly around the building, depending on the lightning protection class, thus never exceeding 20 meters. They shall be connected to the roof mesh and connected to the grounding electrode in lightning boxes.

The lightning protection and grounding system shall be connected at various points at ground level to the main earthing grid. These connections shall be separable for measuring purposes. The used material for lightning conductors may vary from copper if necessary due to installing purposes. In this case special attention has to be paid to the connection type between lightning protection and grounding system to avoid corrosion. Lightning protection conductors shall be installed avoiding sharp bends as far as possible, and using the shortest route to the earthing grid.

Lightning rods shall have a nominal diameter not less than 16 mm and shall be made of the same material as the conductors used for the grid. The end of the rod shall be spikey. Conductors used as lightning protection meshes on building steel roofs shall be at least 80 mm² round zinc coated steel (diameter > 10 mm) or stainless steel (steel number 1.4571 or 1.4404). This size also applies for the down falling conductors to be connected to the floor grounding mesh.

Copper anchorages, mountable on wall, in addition to test clamps with plastic covers shall be used to anchor the copper conductor coming down to ground from roof. All connections in the ground shall be made with thermo welding process.

Additionally to the outer lightning protection, an inner lightning protection according to IEC 62305 shall be delivered. This means SPD (surge protection devices) have to be installed on both sides of incoming services. Also, different protection zones have to be identified and between this zones, SPDs are installed. These SPDs shall be energetically coordinated from coarse to fine to ensure small impact of operation in case of couplings from outside. Before determining all necessary measures to ensure the lightning protection, a risk analysis has to be made.

For the inner lightning protection, potential equalization bars and lightning protection devices have to be installed. For all cables and other conductive materials leading into the protected structures adequate measures have to be taken to prevent lightning surges from interfering with inside equipment or generating intolerable potential rises.

Between different lightning protection zones a potential equalisation busbar has to be installed, where all passing cables and grounding conductors have to be fixed.

The Contractor shall supply all conductors, connection, anchorage and SPD materials necessary for establishing a complete safe and reliable system. Earthworks required for connecting the lightning protection system to the grounding grid shall be carried out by the Contractor.

13.5.2 Buildings

All buildings shall be protected against lightning strikes according to the local conditions. Flat concrete roofs of buildings shall be considered, at the roof surface, with a mesh of 70 mm² stranded copper conductors. The lightning protection system shall consist of copper clad steel arrester rod, roof and down conductor of 70 mm² bare copper.

In case of a steel roof surface, zinc coated steel or stainless steel (steel number 1.4571 or 1.4404) shall be used for easier erection, in this case the minimum diameter is > 10 mm with > 80 mm² area.

The size of the mesh depends on the roof area and shall form roughly 7 m x 7 m squares, depending on the calculated lightning protection class and the roof geometry. All points of the mesh shall be welded together.

The control- and battery room in the powerhouses has to be seen as separate zones, in order to protect these sensible areas sufficiently.

13.5.3 Free areas

For the lightning protection of the free areas (upper and lower reservoir, dam), vertical steel lightning rods shall be used.

Information about quantity, height and distance of the protection equipment has to be supplied by the Contractor by means of calculation reports. The lightning protection system has to be connected to the respective earthing system and shall also be carried out by the contractor.

13.6 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

After installation the system shall be tested both stand alone and as part of the plant commissioning.

All tests shall be carried out according to the manufacturer’s established practice.

After completion of the system, the compliance with the requirements and the effectiveness of the grounding shall be proven by measurement. The actual ground resistance for the systems as a whole shall be measured in conformance with IEEE Standard 80 and compared with the calculated values. Furthermore, touch and step voltages of the installed grounding grid shall be checked in conformance with IEEE Std. 80.

13.7 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

13.8 Documentation

13.8.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

13.8.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15

Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Operation instruction and maintenance handbooks	Technical Report	acceptance test

14 ILLUMINATION AND SMALL POWER INSTALLATIONS

14.1 General

This Specification covers the design, supply and installation of complete indoor and outdoor lighting and small power installations for the project area.

This includes all main- and sub distribution boards for building services, complete small power (socket outlets and power receptacles) systems and normal and emergency lighting.

14.2 Scope of Supply

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the whole illumination and small power installation for the PSPP Manara project.

The several project areas shall be equipped with following main systems:

Powerhouse	Small power installations and illumination system
Upper and lower reservoir	Small power installations and illumination system in the operation building, intake and bottom outlet structure, outdoor lighting in front of buildings/structures and access gate area, flood light on dedicated places around the reservoir, several outdoor socket for maintenance purposes;
Power plant control building, guard house and portal building	Small power installations and illumination system in the buildings, outdoor lighting in front of building, parking areas and access road, flood light on dedicated places, several outdoor socket for maintenance purposes, small power installations and illumination system in the outer cable channel
Access tunnel (main, flexible joint, surge tank, mucking tunnel, portal building)	Small power installations and illumination system in the access tunnels, evacuation routes and entrance areas of hydro-mechanical devices, dedicated positions of sockets for maintenance purposes, small power installations and illumination system along the high voltage cable route;

The contractor guarantees a perfect operation of the equipment and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, wiring, etc. which is needed for the correct operation.

Calculations needed for a state of the art system shall be done by the supplier and forwarded to the Owner for approval. The calculations which are prepared for the illumination and cable sizing shall be summarized in a calculation report.

All components and sub-components of the firefighting and fire detection system of the HEPP have to be in accordance with the latest standards and safety regulations. All drawings needed for the correct installation and the drawings needed for the design of the civil are in the scope of the contractor.

A safety engineer is responsible for writing a safety plan for the buildings, which has to be coordinated with the Israel fire brigade.

The Contractor shall coordinate the detail design of emergency system and apply for approval by Israeli Fire brigade. Finally an integration function test together with all relevant building service supplier according to Israeli Fire brigade shall be held.

The whole equipment installed inside and outside shall be shown in detail at the drawings and have to be mentioned at the part lists of the drawings.

The work for installing, manufacturing erection and commissioning of the different systems is included in the supply of the contractor. Further the scope includes the block-out design for openings in concrete structure, auxiliary constructions for erection of equipment as well as the transport of the whole equipment to side and storage at side.

The routing and block-out design shall be coordinated with the civil design.

The equipment which has to be installed at the plant shall be supplied complete, with all necessary components for its perfect performance and perfect operation even if it is not specifically mentioned here.

All in all the supply comprises basically of the manufacturing, erection, commissioning and testing of the following equipment with all its components and sub-components for the power cavern, the access tunnel, the control building and the outdoor areas in accordance to the latest standards.

14.3 Standards

- IEC 60364 and relevant IEC standards,
- Relevant VDE/DIN standards as applicable to switchboards, switches, cables, conduits, sockets outlets and plugs, to lamp fixtures, fluorescent and incandescent lamps, high-pressure discharge lamps, miniature breakers, etc.
- According to national standards

14.4 General installation requirements

All installations shall be carried out in accordance with best modern construction practice.

Cables and wires shall be enclosed in conduits, boxes or raceways as applicable. Joints and splices shall be made in an approved manner and shall be equivalent to the conductor itself.

Wiring under plaster or concrete finished rooms shall be executed through embedded plastic or metal conduits. Exposed wiring shall be laid in surface mounted heavy duty plastic conduits with corners and edges uncovered. In areas endangered by or subject to mechanical damage, wiring is to be entirely laid through galvanized steel conduits with edge and corner pieces.

All three-phase power outlets shall be supplied with three phases, neutral and grounding terminal and all single-phase power outlets shall be supplied with one phase, neutral and a grounding terminal.

The types of lighting fixtures, sockets, switches etc. shall depend upon the individual conditions of each room or area. In rooms and areas exposed to moisture, chemicals or dirt, the equipment shall be of the outdoor weather-proof type.

Lighting fixtures installed indoors shall be attached to ceilings, walls, trunking or roof steelwork or suspended from there, as appropriate. Rod type suspension units shall be employed for suspended fixtures.

Switches shall be furnished and installed to control the lighting in each room and shall be located near the door. Large rooms, such as machine halls, shall have their lighting controls at the sub distribution centers. The lighting of all corridors and stairways shall be controllable at each end by two-way switches or impulse relays. Lighting for toilets shall be switched by motion detectors

Socket outlet, three phase power receptacles shall be mounted 300 mm above finished floor level, but those for use with workshop benches shall be mounted 150 mm clear of the bench working surface.

Lightning surge protection devices have to be foreseen at all necessary points of the main and sub distribution in the right sizes. Definitely shall there be lightning surge protection at all lines going into our out of buildings.

General, all equipment shall be mounted direct on wall or ceiling, except those installations which are located in office areas or control buildings, that installation shall be flush-mounted.

Single phase socket and outlet, at least 1 pc. for small rooms, 2 pcs. for medium room size; for large rooms or technical rooms such control room, IT room, kitchen and office rooms, workshops, machine hall, generator floor, galleries, erection bay sufficient number of sockets per working place/distance shall be considered.

Three-phase power outlet and sockets shall be installed in sufficient number per working place/appropriate distance for handling of tools in machine hall, generator floor, cable/ventilation gallery, workshops, HVAC room, erection bay, corridor, outdoor area.

14.5 Small power installations

14.5.1 Category of station service

The Station Services are classified in three categories, as follows:

Essential services are those, which maintain mainly the Control and Monitoring

System, the security system, the telephone system and emergency lighting in operation. They shall be available at all times and shall not be affected by any fault on a high or medium voltage circuit, or by a possible shutdown of the main power supply. These services feed the correspondent consumers either directly, with direct current provided by a battery-set, or indirectly with alternating current generated by a DC/AC inverter supplied by the 220 V DC batteries.

Priority services for those consumers where a short interruption of power supply can be tolerated.

General services are those, which are not affected by shutdown of long duration. Their non-availability has not any immediate influence on the power plant operation. These services feed the correspondent consumers with alternating current, from the Station Services' main supply.

14.5.2 Power supply

Power supply for normal lighting and small power systems shall be 400/230 V, three-phase, 50 Hz, four- wire with solidly-grounded neutral, provided by non-essential main distribution board.

All lamps connected to emergency system shall remain lit continuously when the normal lighting is switched on and shall remain lit in case of power failure in alternating current supply.

For each floor/level of the power house an appropriate location for 400/230V building distribution boards shall be defined. This floor distribution shall consist of at least one cubicle for general/non-essential, one cubicle for essential power supply, and one cubicle for remaining systems (local control, terminal box, etc.). Those cubicles each floor are connected by cable latter/tray between and to the main distribution board. The main cable laying within the floor shall be done by cable trays in the corridor mounted on the wall or on ceiling; for extended and large floors two distribution areas shall be defined with two independent boards location (board 1.1/1.2, etc.)

For large rooms, such machine hall, generator floor, workshops or more cables to be installed appropriate cable tray shall be mounted; cable tray/latter shall be split in non-essential and essential, an low voltage distribution.

The power supply for the lighting and small power of the access tunnels shall be split from the control building (1st part of the tunnel) and form the cavern (2nd part of the tunnel).

14.5.3 Conduits, Accessories, connection boxes and ducts

In all areas and rooms normally exposed to view, such as control rooms, access ways, rest rooms, offices, etc., the conduits shall be embedded in concrete or arranged that they are concealed. Elsewhere, conduits shall be surface mounted.

Conduits shall be super-high-impact PVC, heavy gauge, unscrewed, plain ends and of grey colour. Conduit fittings shall be of high-quality manufacture.

In office rooms, meeting room, control rooms, workshops, sockets shall be installed in cable duct system.

14.5.4 Cables, cable terminations and coding

Interconnecting cables between the load centers, main distribution boards and lighting sub distribution boards (LDB) as well as connection cables from the distribution boards to the consumers (lamps, sockets,…) in appropriate protection level shall be furnished and installed by the Contractor, as part of this specification.

Lighting and socket outlet circuits shall be realized with halogen-free insulated cables with copper conductors. The halogen-free material used for conductor insulation and cable sheathing shall be of the highest quality, heat resisting type.

Cables for emergency lighting shall of fire-resistant type and fulfil the criteria of section 11.4.5

The size of the conductors shall be determined on the following bases:

- The minimum conductor size shall be 2.5 mm² for power outlets. These sizes of conductors may be standard electric wires.

- The minimum conductor size for branch lighting circuits shall be 1.5mm², and the minimum conductor size for the circuit from the last fixture to the nearest lighting panel shall be 2.5 mm².

- The conductor size shall be sufficient to keep the voltage drop to the furthest lighting point, under normal full load conditions, to no greater than 3%, or as specified in the DIN, VDE and/or IEC standards.

- The conductor size shall be adequate for the current to be carried, as set out in the cable manufacturer's specifications.

The color coding to be used shall be in accordance with the prevailing Standards. Color coding per IEC or VDE/DIN standards, will be allowed if expressly agreed by the Owner.

14.5.5 Socket outlets and switches

Single-phase socket outlets shall be three pin type and shall comply with the requirements of applicable standards.

Heavy-duty three-phase socket outlets shall be five pin type, and shall comply with the applicable standards.

Heavy-duty socket outlets shall be equipped with a one or three-pole miniature circuit breaker available locally. The same applies for heady machinery directly connected to the distribution boards as wished by the customer.

Socket outlets shall be arranged for surface or flush mounting in single or two gang units as appropriate. Each socket outlet for outdoor use shall be weather proof.

Lighting switches shall be single-pole type. Switches shall either be of the tumbler or rocker dolly type.

Lighting switches (10 A) and socket outlets (16 A single phase, three pins) installed in rooms with embedded wiring shall be designed for flush-mounting in moulded-plastics wall boxes. In all other cases, exposed mounting with shock-proof plastic housings of adequate enclosure shall be provided.

Switches shall be one way or two way as required and multi-gang variations are to be provided as appropriate.

The conductor size shall be sufficient to keep the voltage drop to the furthest power point, under normal full load conditions, to no greater than 5%, or as specified in the DIN, VDE and/or IEC standards.

14.5.6 Three phase power socket outlets and plugs

The power socket-outlets and plugs shall be installed in various places of the power plant. These receptacles will be used mainly during the erection period and for maintenance or equipment repair, to connect a sub distribution panel on which all kinds of electrical machinery would then be connected (welding machines, drilling machines, grindstones, removable drainage pumps, etc).

The power socket outlets and plugs shall be of the CEE type, weather-proof, with housings of shock-proof plastic material. The following types of socket outlets shall be provided at locations to be approved by the Owner.

- Three –phase socket-outlets of 32 A and higher ratings as required with five pins and incorporated switch and mechanical interlocking
- Single-phase socket outlets of 16 A and higher ratings as required with three pins
- Solid rubber junction boxes/enclosure (power distribution board IP44, 3 single phase 16A 250 V, 16A CEE, 32 A CEE), a combination of individually-fused (RCD, MCBs), three phase sockets of each type required, single phase

socket outlets shall be provided, at special locations (for example operation levels, machine hall, generator floor, workshops),

Outdoor installations subject to sun radiation shall be provided with shields. At hot locations, metallic housings suitably protected against corrosion are required.

The exact location of power socket outlets shall be determined during the detailed design phase, when construction drawings are being finalized.

Power socket outlets shall generally be wall mounted 1200 mm above ground level, in locations where they are protected from accidental damage due to handling, erection, maintenance work, quid dripping, exhaust gases, etc.

14.5.7 Lighting and sub distribution panels

All main and sub distribution panels shall comply with the requirements specified in the "General technical specifications".

14.6 Illumination

14.6.1 Normal lighting

The lighting of the indoor areas and the access tunnel shall preferably be carried out by LED technology. For the outdoor areas protected spotlights shall be used.

The lighting shall be designed in such way to reach the proposed illumination levels as defined below.

The average illumination level of each place measured at a height of 1 m above the floor shall be as indicated in these lists. The ratio of initial illumination and average illumination (uniformity) shall be 1.5 / 1 for indoor spaces and 5 / 1 for outdoor spaces.

Lighting shall be free of glare, especially in the control room, where special attention shall be paid to the problem of admissible reflections of lighting sources in the instruments of the panels.

In rooms and locations equipped with electrical panels, switchboards etc., fixtures shall be mounted in such a manner as to avoid any danger for working men (e.g. changing bulbs or lamps, cleaning, maintenance etc.) near the energized parts of these installations.

Groups of fixtures shall be distributed such as to result in a balanced loading of the three phases of the supply system. Special attention shall be paid to the fact that for locations where rotating machines are installed in rooms, stroboscopic effects are avoided.

The lighting fixtures shall be arranged neatly without interference with other equipment to provide substantially uniform level of illumination throughout the room or area illuminated, eliminating dark corners.

14.6.2 Emergency lighting

A secondary lighting system fed from the monitored central battery computerized Power Supply (UPS) shall be provided in the powerhouse, main access tunnel, related buildings and switchyard to maintain emergency lighting in the event of complete loss of all AC supply.

The emergency lighting has to fulfil local regulations and I.S. certifications regarding location, equipment, central battery system aso.

The emergency lighting shall be carried out using LED technology.

Emergency luminaries, independent of the normal luminaries, shall be mounted appropriately to provide sufficient illumination of minimum of 10 Lux on stairways, passages, dangerous locations and uncovered openings. Additional emergency fixtures shall be installed in the operating centers, such as the control room near to centralized control boards apparatus room, near to local panels etc. in such a manner to maintain a minimum illumination level of 50 Lux.

The installation of the emergency lighting system shall not physically be placed together with the normal lighting system, but in two different cable tray systems and shall be wired such that they are independent of each other and performed according to DIN 4102/12 in NHXH F180 E-90 cable.

Emergency luminaries shall be mounted in such a way that under normal operating conditions a sufficient number of them will be in operation in addition to the normal luminaries.

Emergency lamp holders shall be red marked for easy identification. Fixtures containing emergency lamps shall also be marked with red as approved by the Owner.

For the cabling of the access tunnel lighting halogen free fire resistant cables (E90 / FE180) shall be used. The power supply of the emergency lighting of the access tunnel is from the central unit of the control building for the 1st part and from the central unit in the cavern for the 2nd part of the tunnel.

The emergency lighting is part of the emergency evacuation system providing visual information to the power plant personnel. The overall firefighting and emergency evacuation concept shall be coordinated and approved by the Israel Fire Brigade.

14.6.3 Battery powered portable emergency lamps

Battery powered portable emergency lamps shall be supplied for all relevant locations.

Every battery powered portable emergency lamp shall be provided with its own charging station. If the power supply of the normal lighting system fails, the emergency lamps shall be automatically switched on.

The charging stations shall be wall mounted. The number and location of the battery powered emergency lamps shall be chosen to ensure safe evacuation from the concerned location.

14.6.4 Illumination levels

Illumination levels in major areas shall be as follows:

Entrance room	100 lux
Corridors	100 lux
Offices	400 lux
Telecommunication room	300 lux
Control Room	400 lux
First Aid Room	300 lux
Kitchen / Lunch Room	150 lux
Locker Room	100 lux
W.C.	70 lux
Electrical / Mechanical Workshop	200 lux
Battery Room	100 lux
Storage Rooms	80 lux
Machine Hall	200 lux
Transfer Hall	200 lux
Erection Area	200 lux
Turbine Floor	150 lux
Turbine Pit	150 lux
Inlet Valve Chamber	80 lux

Roads	20 lux
Transformer Area	100 lux
Intake and Spillway	80 lux
Gallery and Cable corridors	30 lux
Fire Pump Room	100 lux
Compressor room	100 lux
HVAC Room	100 lux
Diesel Room	100 lux
Staircases	100 lux

The following reflection coefficients shall be taken into consideration in illumination calculations:

For ceiling	70%
For walls	50%
For floor	20%

In addition maintenance factor 75% shall be taken for lighting fixtures.

Emergency lighting in other indoor areas shall be ensured by battery powered portable emergency lamps.

14.6.5 Control of lighting

Lighting fixtures in self–contained rooms such as offices, switchgear rooms, battery rooms, etc., shall be switched locally. Where more than two switching points are required (staircases, large rooms or halls with several entrances, etc.) push button switches shall be used to control impulse-operated relays and contactors arranged in the associated sub-distribution boards. All other circuits shall directly be controlled from the relevant distribution boards. Outside lighting shall be controlled by photo-electric switches and motion detectors.

14.6.6 Lighting fixtures

All lighting fixtures complete with lamps, tubes, instant starting control gear, chokes, compensating capacitors, etc., shall be of approved manufacturing, constructed from best quality materials and provided with all necessary installations. Outdoor fittings shall be completely weather proof.

Special precaution shall be taken to protect the wiring from damage of heat generated by fittings and lamps. For compensation of the inductive current of the chokes, compensating capacitors shall be provided to obtain approximately unity power factor. To avoid electrical shocks when touching disconnected fittings, which includes capacitors, discharge resistors of sufficient size shall be connected in parallel with all capacitors of more than 0.5 micro farad capacitance.

According to the IEC regulations, the equipment shall be furnished with radio interference suppressors if the maximum interference voltage stated in the regulations is exceeded.

The diffuser of fixtures indicating e.g. emergency exits shall be fitted with a green colored, translucent foil bearing inscriptions or symbols approved by the Owner.

14.6.7 Preferred types of lighting

Followings types of lighting shall be considered in the building installation.

Purpose	General lighting in all areas, except office areas
Performance	LED technology similar to 1/2 x T16 with 35 / 49 / 80 W
Reflector	Made of PMMA, clear mirror from highly reflective aluminium, coated, high-gloss, extremely wide distribution
Light emission	direct distribution, symmetric characteristic
Installation type	suspended mounting, surface-mounted
Control gear	ECG Multi watt, 230 V AC, 50Hz
Luminaire housing	Made of glass-fibre reinforced polyester, uncoated, bright grey
Protection rating (complete)	IP65
Labels	CE Conformity
Figure	

Purpose	Office lighting
Performance	LED technology similar to 2 x T16 with 28 / 54 W
Reflector	Made of highly specular aluminium, primary anti-glare with specular louvre
Light emission	direct distribution, symmetric characteristic
Installation type	Lay-in mounting, recessed
Control gear	ECG Multi watt, 230 V AC, 50Hz
Luminaire housing	Made of coil coated, pure white sheet steel
Protection rating (complete)	IP20
Labels	CE Conformity
Figure	

Purpose	Office area, corridors, toilet areas
Performance	LED technology similar to 2 x 16/18 W
Reflector	Made of highly specular aluminium, primary anti-glare with specular louvre
Light emission	direct distribution, symmetric characteristic
Installation type	Lay-in mounting, recessed
Control gear	ECG Multi watt, 230 V AC, 50Hz
Luminaire housing	Made of coil coated, pure white sheet steel
Protection rating (complete)	IP20
Labels	CE Conformity
Figure	

Purpose	Public areas and outdoor
Performance	LED technology similar to 2 x TC-LEL with 18 W
Reflector	Made of opal PMMA
Light emission	direct distribution, symmetric characteristic
Installation type	surface-mounted
Control gear	ECG, 230 V AC, 50Hz
Luminaire housing	Made of uncoated, white PC, square, white coated sheet steel clip for enclosure
Protection rating (complete)	IP65
Labels	CE Conformity
Figure	

Purpose	Machine hall
Performance	1 x HIT-DE / HST-DE with 250 / 400 W
Reflector	Aluminium soft facetted
Light emission	wide distribution
Installation type	suspended mounting
Control gear	ECG, 230 V AC, 50Hz
Luminaire housing	Made of coated aluminium, metallic grey
Protection rating (complete)	IP20 (IP65 with cover sheet)
Labels	CE Conformity
Figure	

Purpose	Floodlight for outdoor lighting
Performance	1 x HIT-DE / HST-DE with 400 W
Reflector	Cover panel of toughened safety glass, highly specular aluminium reflector
Light emission	direct distribution, asymmetric characteristic
Installation type	Surface-mounted
Control gear	LLCG, with thermal protection switch, parallel p.f. corrected, reducing circuit with relay and timer
Luminaire housing	Made of coated aluminium, metallic grey
Protection rating (complete)	IP66
Labels	CE Conformity
Figure	

Purpose	Outdoor lighting with light pole
Performance	1 x HSE with 250 W
Reflector	Transparent enclosure of PMMA, radial facetted optic of aluminium
Light emission	direct distribution, symmetric characteristic
Installation type	Side-entry, post-top
Control gear	LLCG, with thermal protection switch, parallel p.f. corrected, reducing circuit with relay and timer
Luminaire housing	Made of coated aluminium, light grey
Protection rating (complete)	IP65
Labels	CE Conformity
Figure	

Purpose	Emergency lighting
Performance	LED technology
Reflector, Light emission	Acrylic glass panel with escape sign printed on one or both sides, single-sided escape sign printed in white on rear,
Installation type	surface-mounted, ceiling recessed,
Control gear	ECG, 230 V AC, 50Hz
Luminaire housing	Housing made of extruded aluminium section
Protection rating (complete)	IP20 or higher
Labels	CE Conformity
Figure	

Purpose	Battery powered portable emergency lamps
Figure	

14.7 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement of the installations
- Function test of overall system including interfaces to the other suppliers
- Function test of overall alarm and firefighting control system in the presence of the national fire brigade

14.8 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

14.9 Documentation

14.9.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

14.9.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3

Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 months acceptance tests

15 SECURITY SYSTEM

15.1 General Description

The purpose of the integrated security and surveillance system shall be to achieve a good level of protection against all potential risks of intrusion and to contribute to the process, equipment, and personnel safety through IP based Video Surveillance System (VSS) via a Closed Circuit TV System (CCTV).

15.2 Scope of Supply

The system and installation shall comprise the following subsystems:

- Video Surveillance System (VSS) via Closed Circuit TV System (CCTV)
- Access / Intrusion Alarm System by means of motion detectors

The Contractor shall submit to the Owner for approval detailed application drawings with complete wiring including riser diagram and necessary technical data.

The system shall feature the most modern technology and philosophy available. Should the contractor at the time of implementation have equipment available of newer design and functionality, such systems will be provided as long as the functionality and performance is equal or better than the equipment described in this specification subject to the Owner´s approval.

15.3 Specific standards

All the systems and components shall be EMC certified according to the applicable International standards and shall comply with EMI / RFI International safety standards such as IEC and EN, some of which are referenced below:

15.4 Design Particulars

15.4.1 Video Surveillance System

A video surveillance system (VSS) shall be based on IP technology, (IP CCTV) and shall be provided for effective surveillance of the critical points of the Plant. The systems shall be fully digital, flexible and scalable and provide the users with the ability to monitor and record video over IP networks (LAN).

Videos from high resolution Network IP color/ black-white cameras shall be digitized and compressed by the network cameras, and shall be transported over the IP-based network. The network shall be implemented through Industrial Ethernet switches supporting 100 MBps or better bound rate.

The cabling shall be carried out as CAT 6 type which will be used for to the telephone and IT applications. All cables shall be connected to 19” cable distribution panels/cubicles. The cable distribution panels/cubicles shall be part of the cabling.

Powerhouse	20 data sockets
Upper reservoir / operating building	1 data sockets, outdoor
Lower reservoir / operating building	1 data sockets, outdoor
Access tunnel	6 data sockets
Operating building	2 data sockets, indoor 2 data sockets, outdoor
Guard house building	1 data sockets, outdoor

The Video Management Server shall be a latest technology PC equipped with Video Management software running on standard commercial file Server (Linux, Windows) for viewing, playback, administration and recording.

Alternatively, video files can be recorded to a NAS (Network Attached Storage) device.

Video Management Software shall be provided for the VSS. The digital Video Management Software shall be installed in the server and PC of the VSS and shall support the following functions:

- Real Time Viewing and Recording of digital video continuously. Multi-users viewing. Full motion (25frs) viewing.
- Simultaneous display, playback, export, distribution and archive of multiple videos and audio.
- Video loss detection shall provide, upon loss of a video input, an alarm message generated on the display screen whilst providing an external alarm condition.
- Video / Camera Sabotage protection, shall monitor the system to detect de-focus, re-directing or covering of the camera providing a subsequent alarm message on the display screen and whilst providing an external alarm condition.
- Compression format shall be MPEG4, JPEG or H.264 with hashed images exported using a 512-bit digital signature.
- Event and Event Filter will provide a tool for quick search of event/alarm by filter type: time, video loss, video sabotage, VMD, alarm and - intrusion alarm.
- Search Expert shall provide a method of searching stored images for activity in defined regions of interest between defined time periods.
- Multiple camera searches can be applied, with advanced filters to define size, speed and direction of movement.

The VSS shall be suitable for integration with an Intrusion Alarm and the Fire Detection System. Alarms from the Fire Detection System shall be used to trigger functions in the video systems, such as to automatically display on the monitors the areas covered by the corresponding cameras, store images related to the events, live announcements at the camera site (for the cameras configured with speakers at the perimeter fence).

The fixed network cameras shall be installed at critical points of the power plant. Flexible dome cameras shall be located in outdoor areas, controlled remotely over the network using the GUI of the VMS. All settings (I/O), Pan, Tilt, Zoom (PTZ), automatic and manual of the cameras shall be performed over the same network that transports the video.

Following numbers of cameras are foreseen:

Powerhouse	14 fixed cameras in corridors, at the entrance of staircases 2 fixed in machine hall
Upper reservoir / operating building	1 flexible dome cameras, outdoor with PTZ functionality
Lower reservoir / operating building	1 flexible dome cameras, outdoor with PTZ functionality
Access tunnel	6 fixed cameras at the gates, crossings, surge tank and flexible joint, mucking tunnel
Operating building	2 fixed cameras in corridor, at the entrance 2 flexible dome cameras, outdoor with PTZ functionality
Guard house building	1 flexible dome cameras, outdoor with PTZ functionality

Housing of cameras meant for indoor use shall be of IP42 rating, whereas outdoor and process areas camera housing shall be of IP65 or better rating.

The outdoor cameras shall be installed with pole.

The signals of the video surveillance shall be available also for the control system.

Thermostatically controlled built in fans for cooling, heaters and defoggers should be provided for all outdoor cameras. The housing of the outdoor cameras shall be of UV resistant material with sun shields.

15.4.2 Access and Intrusion

For each main entrance area motion detector sensors shall be installed, which are connected and evaluated in the control system.

Following numbers of sets are foreseen:

Power cavern	Entrance area access tunnel to power cavern gates at machine hall level
Access tunnel	Entrance area access tunnel portal, surge tank and flexible joint, mucking tunnel portal
Operating building	Corridors, entrance door
Guard house building	Entrance door

15.5 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement of the installations
- Function test of overall system including interfaces to the other suppliers
- Function test of overall alarm and firefighting control system in the presence of the national fire brigade

15.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

15.7 Documentation

15.7.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

15.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15

Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 month before acceptance tests

16 TELEPHONE SYSTEM AND IT-CABLING

16.1 Scope of supply

This specification covers the automatic telephone branch exchange and it's auxiliaries as specified below.

- Private automatic telephone branch exchange (PABX) and it's auxiliaries which shall include battery, charger, telephone sets and necessary accessories

- Structured cabling type CAT6, suitable for telephone and desktop computers, including 19 inch patch panels, distribution cubicles

The scope shall include all components and other systems which are required for performance, durability and satisfactory operation of the equipment even though not individually or specifically stated in these specifications.

Preparation of detailed application drawings for approval by the Owner in accordance with this specification. These application drawings shall show all wiring, distribution boxes, and number of spare terminals and wires.

The supply and installation of the communication cables related to the telephone system, testing, commissioning and delivery of complete system in operating condition.

Telephone cabling between the switchyard control building and the IECo metering room inside the powerhouse. These cables shall be dedicated for IECo, the type of the cables will be provided by IECo at a later time.

16.2 Specific standards

The applicable standards shall correspond to those used by the national authorities. At least, the proposed system and equipment shall fulfil the requirements of the IEC standards and of the VDE standards, as well as those of CCITT (International Telegraph and Telephone Consultative Committee).

16.3 General requirements

The entire power plant shall be equipped with a telephone system consisting of a main exchange. This system shall take over the internal and external telephone traffic of power cavern, operating buildings, guardhouse and other facilities.

The system shall be compatible to an ISDN (Integrated Services Digital Network) and Voice-over-IP (IP phone). The PABX shall correspond with the public telephone grid and/or the communication through optical fibers via the external lines.

The sub telephone exchange systems, located on dedicated places of power plant area, shall have technically the same structure as the main telephone exchange and shall be connected preferably via optical fibre cable with the main telephone exchange. All necessary modems, communication equipment and fibre optic cables shall be included in the supply.

The telephone system shall be used for internal communications between all parts of the power plant and for the connection of external exchange lines in such manner that any incoming call can be extended to any internal telephone.

With the private automatic branch exchange (PABX), all local subscribers shall be able to intercommunicate selectively with one another as well as place or receive trunk-calls via trunk-call selectors, provided the subscriber is authorized for free external traffic.

The possibility must be provided to select whether a subscriber can participate in external traffic or not. Subscribers which are authorized for external traffic can cut in during a trunk-call if necessary. Each subscriber can individually be authorized for local cut-in.

Private automatic branch exchange	2 x ISDN So-channel, max. 20 users analog (a/b), max. 24 users digital, max. 96 IP users, max. 16 cordless office sets
Standard phone set	Digital and IP set, eight function keys with LEDs, Hands-free mode, Two control keys (+/ -), Suitable for wall-mounting
Advanced phone set	Digital and IP set, alphanumeric LCD display showing two lines of 24 characters each, three dialog keys for interactive menu (OK, Back, and Next), desk sharing and flexible office environments
Cordless / W-LAN mobile phone set	Cordless and/or wireless mobile hand set, containing of mobile and base station for installing in machine hall or office areas

The subscriber shall be installed in office and meeting rooms, control room, technical room, workshop, and central places in corridor. The subscriber sets shall be of the desk or wall type.

Following numbers of sets are foreseen:

Power cavern	2 advanced phone 8 standard phone 2 cordless mobile set
Upper reservoir / operating building	1 standard phone
Lower reservoir / operating building	1 standard phone
Access tunnel	2 standard phone
Power plant control building	2 advanced phone 8 standard phone 2 cordless mobile set
Guard house building	1 standard phone
Main gate	1 door intercom phone

At the main gate of the power station an interphone shall be installed, with communication to the main control room.

The telephone switching equipment shall be of space-saving, compact and modular design. All modules shall be easily accessible as well as easy to handle.

The power supply of the telephone system shall be independent from the DC power supply of the power plant. The power supply shall consist of battery chargers and batteries with the required capacity to operate the telephone system during a prolonged time of power failure in the 400 V AC system.

The PABX shall be of advanced design and construction according to modern technology and microprocessor controlled. Switching devices shall be of high reliability and shall be of semiconductor type.

All equipment shall be installed in lockable, dust-proof and standard size cabinets. If possible, they shall be of the same type as used for other similar equipment.

The Contractor shall furnish distributing frames which shall terminate all cables to and from the telephone equipment. Necessary interconnections shall be made on this frame. Each subscriber circuit shall be equipped with surge protective devices.

Lightning protection (SPD1) at the point of entering a building shall be considered.

It is supposed that the Israel fire brigade may require a dedicated communication and telephone land line for the fire system dailer in the operation building. Adequate communication equipment and capacity shall be considered.

The “on-duty” staff or “on-call” staff shall be warned by the Alarm Broadcast System in case this latter detects any alarm or failure whether or not a local or remote action is required. Meaning, telephone system shall provide hardware interface with 8 pcs. contacts to connect to the power plant control system for several alarm groups. Each input shall linked to a programmable text memory unit providing individual text message. The telephone unit shall dial to predefined user´s mobile automatically and sending warning text.

16.4 Cabling

The cabling shall be carried out as CAT 6 type which will be used for to the telephone socket (RJ11) and IT applications (RJ45). All cables shall be connected to 19” cable distribution panels/cubicles. The cable distribution panels/cubicles shall be part of the cabling.

Powerhouse	20 data sockets 20 telephone sockets
Upper reservoir / operating building	1 data sockets 1 telephone sockets
Lower reservoir / operating building	1 data sockets 1 telephone sockets
Access tunnel	2 data sockets 2 telephone sockets
Power plant control building	20 data sockets 20 telephone sockets
Guard house building	1 data sockets 1 telephone sockets
Main gate	1 door intercom

16.5 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

<u>Factory Tests</u>

Routine tests of each component shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

<u>Field tests</u>

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement of the installations
- Function test of overall system including interfaces to the other suppliers
- Function test of overall alarm and firefighting control system in the presence of the national fire brigade .

16.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

16.7 Documentation

16.7.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

16.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 month before acceptance tests

17 RADIO COMMUNICATION

17.1 Scope of Supply

The purpose of this system is to provide communication system for operating personnel for the overall project area, in- and outdoor. This Specification shall cover the design, supply and installation of complete system.

17.2 Specific standards

The applicable standards shall correspond to those used by the authorities. At least, the proposed system and equipment shall fulfil the requirements of the IEC- and VDE Standards as well as those of CCITT (international Telegraph and Telephone Consultative Committee).

The system design need to be coordinated with and approved by the national authority for telecommunication.

The radio communication system is part of the emergency evacuation system providing acoustic information to the power plant personnel. Therefore hardware interface to firefighting and detection system for announcing shall be provided. The overall firefighting and emergency evacuation concept shall be coordinated and approved by the Israel Fire Brigade.

17.3 Design Particulars

The power plant shall be equipped with Nitzan wireless radio communication system consisting of one fix call station with channel selecting and control unit located in the control room, transmitter and receiver, repeater and amplifier units, indoor and outdoor antennas, radiating cables and associated power and signal cabling.

Powerhouse	Indoor antenna/radiating cable for main corridors, machine hall, generator floor, office area, workshops,
Upper reservoir / operating building	Outdoor antenna
Lower reservoir / operating building	Outdoor antenna
Access tunnel	Radiating cable/outdoor antenna for whole tunnel, entrance area access tunnel portal, surge tank and flexible joint, mucking tunnel portal
Operating building	Indoor and outdoor antenna

The system shall have 2 digital radio channels in the frequency range of VHF (70cm band, 380-470 MHz).

The antennas shall be spitted in indoor antennas and radiating cable for power cavern and access tunnel, and outdoor antennas for control building and reservoirs building areas.

For staff use 5 digital mobile devices shall be delivered.

The design services shall comprise a radio measurement and propagation analysis of the project area.

The radio system are connected to existing free-field radio networks of the operating personal in such a way that the radio communication in the power cavern and access tunnel is the same as outside, without restrictions. All radio channels shall be transmitted in parallel without mutual interference.

The system shall be fed by emergency power supply of the plant.

The “on-duty” staff or “on-call” staff shall be warned by the Alarm Broadcast System in case this latter detects any alarm or failure whether or not a local or remote action is required. Meaning, radio communication system shall provide hardware interface with 8 pcs. contacts to connect to the power plant control system for several alarm groups. Each input shall linked to a programmable text memory unit providing individual text message. The system shall dial to predefined user´s mobile automatically and sending warning text.

17.4 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement of the installations
- Function test of overall system including interfaces to the other suppliers

- Function test of overall alarm and firefighting control system in the presence of the national fire brigade

17.5 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

17.6 Documentation

17.6.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

17.6.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10

Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 month before acceptance tests

18 CLOCK SYSTEM

18.1 Scope of Supply

This specification covers one master clock and eight slave clocks of various types and sizes for installing at locations indicated below.

The work shall cover the design, engineering, delivery, installation and commissioning of the system.

- Preparation of detailed application drawings in accordance with this for the approval of the Owner.
- Furnishing of a master clock, clocks and special boxes for mounting the clocks to the wall all conduits and wiring.
- The supply and installation of the cables related to the clock system.

18.2 Design Particulars

The master clock shall continually synchronize slave clocks throughout the power plant. The system shall synchronize all clocks to each other. The system shall utilize GPS technology.

The clocks shall be synchronized at least 6 times per day, and the system shall have an internal oscillator that maintains plus or minus one second per day between synchronizations, so that clock accuracy shall not exceed plus or minus 0.2 seconds. The system shall include an internal clock reference so that failure of the GPS signal shall not cause the clocks to fail in indicating time.

The system shall be battery powered for at least 10 hours.

The system shall incorporate a "fail-safe" design so that failure of any component shall not cause failure of the system. Upon restoration of power or repair of failed component, the system shall resume normal operation without the need to reset the system or any component thereof.

For the connection of the master unit to the slave units adequate signal and power cabling system shall be provided.

Powerhouse	Main corridors	4 x analog type
	Office rooms	2 x analog type
	Control room	1 x digital type 1 x analog type
	Workshops	2 x analog type

	Machine hall	2 x big size analog type
Power plant control building	Main corridors	2 x analog type
	Control room	1 x digital type 1 x analog type

The types of slave clocks are as follows:

Analogue type with dial approximate 300 mm, on side indication, black figures on white ground, figures for hours, minutes, with pointers for hours, minutes and seconds.

Analogue type, big size, dial approximate 900 mm, one side indication, flack figures on white ground, figures for hours, minutes, with pointers for hours, minutes and seconds.

Data type with rectangular casing approximate 600x200 mm, one side indication, figures for days, months, hours and minutes, red figures on black ground. Arrangement of figures preferably in two rows.

18.3 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings

- Insulation measurement of the installations
- Function test of overall system including interfaces to the other suppliers

18.4 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

18.5 Documentation

18.5.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

18.5.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10

External connections diagrams for installation	Design Drawing	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Operation instruction and maintenance handbooks	Technical Report	2 month before acceptance tests

19 PUBLIC ADDRESS SYSTEM

19.1 Scope of Supply

This specification covers the address system for the power cavern as specified below.

The public address system shall be used for speech announcements and also as support system for alarm announcements with predefined texts (e.g. fire alarm) to the operating personnel.

The Contractor shall submit to the Owner for approval detailed application drawings with complete wiring including riser diagram and necessary technical data.

The public address system shall feature the most modern technology and philosophy available. Should the contractor at the time of implementation have equipment available of newer design and functionality, such systems will be provided as long as the functionality and performance is equal or better than the equipment described in this specification subject to the Owner´s approval.

19.2 Specific standards

The applicable standards shall correspond to those used by the authorities. At least, the proposed system and equipment shall fulfil the requirements of the IEC- and VDE Standards as well as those of CCITT (international Telegraph and Telephone Consultative Committee).

19.3 Design Particulars

The overall system consists of:

- Voice alarm and call station; a flexible microphone stem and a unidirectional condenser microphone, selecting up to 6 zones, LED indications for zone selection, fault, and emergency state;

- Voice alarm and message control unit; including full system supervision, loudspeaker line impedance supervision, message manager, a supervised emergency microphone on the front panel and a supervised message manager pre-recorded announcements and evacuation messages, 12 contact trigger inputs for business and emergency calls, each can be configured for a message consisting of a sequence of up to eight wave files, 6 zone output;

- Power amplifier units;

- Loudspeakers;

- Power and signal cabling;
- Data and patch panels / cubicle

The call station shall be located at operators desk, the control unit, power amplifiers and patch panels for the cabling shall be placed in the control room in appropriate cubicles.

The area shall be equipped with speakers following areas

Powerhouse	machine hall, generator floor, workshops, control room, office rooms, main corridors, dining room, kitchen
Power plant control building	main corridors, dining room

The public address system is part of the emergency evacuation system providing acoustic information to the power plant personnel. Therefore hardware interface to firefighting and detection system for announcing shall be provided. The overall firefighting and emergency evacuation concept shall be coordinated and approved by the Israel Fire Brigade.

For the cabling fire resistant cables (NHXH E90 / FE180) shall be used.

The proposed public address system shall have extension capability. The ultimate estimated extension range of the system hardware shall permit the system extension by app. 50 percent beyond the initial installation, unless otherwise approved by the Owner at a later date.

19.4 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement of the installations
- Function test of overall system including interfaces to the other suppliers
- Function test of overall alarm and firefighting control system in the presence of the national fire brigade

19.5 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

19.6 Documentation

19.6.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

19.6.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6

Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	2 month before acceptance tests

20 COOLING WATER SYSTEM

20.1 General Description

In order to provide cooling water to all consumers in the PSPP Manara power cavern one autonomous cooling water system shall be provided. The system shall be carried out as a twin loop system with a primary and secondary loop which corresponds to a state of the art cooling water system. The thermal connection between the two loops of the cooling water system shall be carried out with heat exchangers. The primary loop shall be carried out as an open loop supplied with water out of the draft tube. The secondary loop shall be executed as closed loop.

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the cooling water system needed for the supply of one (1) hydroelectric power generating unit. The contractor guarantees a perfect operation of the system and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, piping, wiring, access platforms etc. which is needed for the correct operation of the twin loop cooling water system.

The cooling water system for the unit is schematically shown in drawing MANARA/BD/MD/05/003.

20.2 Design Conditions

20.2.1 Water Supply and performance requirements

The detailed temperature conditions for the raw water supply of the cooling water system can be found in the climate conditions section of the general technical specifications.

In general the maximum design raw water temperature at the entrance into the primary loop shall be 30°C. The maximum temperature of the primary loop water discharging into the tail-race shall not exceed 36°C.

Further, the maximum secondary loop water temperature leaving the intermediate heat exchanger (supply water temperature) shall not be more than 36°C.

The maximum flow velocity in the cooling water system shall not exceed 2,5 m/s.

Heat exchangers, filters, strainers etc. shall be designed for cold water differential working pressure rating of minimum 16 bar.

Water required for the unit’s cooling purposes as well as for the unit seal water supply needs is drawn from the draft tube of the unit 1. During turbine or pump operation of the plant, the water will further also be returned into the unit´s draft tube.

The cooling water system shall supply cooling agnet for the following components in the main power cavern:

Out of primary circuit:

- Turbine shaft seal
- Turbine runner seals
- other systems

Out of secondary circuit:

- Upper generator bearing
- Generator coolers
- Lower generator bearing
- Turbine bearing
- Governor
- High pressure compressed air system
- HVAC system, cooling
- HVAC system, heating
- Main transformers
- Other consumers

As already mentioned, the abstraction and the release of water for supply of primary loop of cooling water system will be done at the draft tube of the installed pump turbine. In reference to safety reasons the location for connection of the pipes to the draft tube shall be upstream of the draft tube gates.

All components in the cooling water system of the unit shall follow a 2 x 100 % redundancy policy in order to reach the highest possible reliability of the system. That is to say 1 pump/filters/heat exchangers can cover 100 % of the cooling water demand; the 2nd component is 100% redundant.

The primary loop for the unit of the PSPP Manara (open loop to the draft tube) will contain two (2) automatic back flash filters, two (2) booster pumps and two (2) plate heat exchangers as a thermal connection to the secondary loop. Further the first loop of the cooling water system is responsible for the turbine sealing water supply and additionally the firefighting system will also be supplied by water out of the first loop of the cooling water supply.

The secondary loop for cooling water supply of the pump turbine (closed loop) will distribute the cooling water to the unit components in the power cavern. The circulation of the water will be done through two (2) circulating pumps of the same type as in the primary loop in order to keep spare parts and maintenance costs low.

According to the 2 different operation modes of the power generation unit, the cooling water system must adapt to the different operation mode to minimize the risk of overheating. So the primary loop shall be equipped with a piping system, guaranteeing the cooling water supply in each of the two (2) operation modes of the PSPP Manara.

Especially in synchronous condenser mode (without circulation in the waterways) the function of the cooling water system has to be guaranteed. To handle this load cases, the piping of the primary loop will be equipped with and additional bypass pipe and additional valves as it is shown in cooling water system scheme MANARA/BD/MD/05/003. The additional by-pass pipe is connecting the return water side of the primary loop with the drainage and dewatering system of the power plant.

Instead of using the connection from the cooling water system back to the draft tube of the pump turbine, the hot water will be released to the lower reservoir by using an additional by-pass pipe.

Further the primary loop of the cooling water system is responsible for the turbine shaft seal and runner seal water supply. An additional connection to the primary loop shall be provided for the supply of other components of the power cavern.

The secondary loop of the cooling water system, (closed loop) will distribute the cooling water to all consumers in the power cavern. The circulation of the water will be done through two (2) circulating pumps, if possible of the same type as in the primary loop in order to keep spare parts and maintenance costs low.

The circulating pumps in the cooling water system secondary loop of the unit will follow a 100 % redundancy policy in order to reach the highest possible reliability of the system. That is to say 1 pump can cover 100 % of the cooling water demand, the 2nd component is 100 % redundant. All pumps shall be equipped with a frequency converter in order to regulate the pumping capacity in the most efficient way.

The required quantity of cooling water is preliminarily approximated with 350 l/s but shall be updated according detail system layout.

Before and after the automatic washing filters manometers shall be provided for checking the pressure of the cooling water.

20.2.2 Distribution of Pumpturbine / Motorgenerator cooling water

Limit of supply is the connection point of the cooling water main supply pipe to the unit cooling water distribution battery in the area of the pump turbine / motor generator floor. The limit of supply is shown on the related drawing. The connection point is direct in the area of the cooling water consumer.

The assemblies between the cooling water system and terminal flanges of the apparatus using the cooling water shall be made by machined flanges in accordance with standard DIN EN 1092-1 and corresponding gaskets.

The location of the hand over flange to other Contractors shall be in the near area of the actual cooling water consumer. That is to say the connection point of the cooling water for the motor generator will be near the motor generator consumers, for the HVAC system in the HVAC room of the power cavern, for the transformers in the related rooms of the power cavern and so on.

The water for the shaft seal and runner seal will be taken from the pre-filtered cooling water system and will be additional filtered with a cyclone filter based on the Contractors requirement

20.3 Equipment Particulars

20.3.1 Intermediate heat exchanger

The intermediate heat exchanger shall be wide gap, plate type capable of transferring all the heat gained during the circulation through the various equipment coolers to raw water. As alternative tube bundle heat exchangers can be offered.

Temperature indicators and remote temperature detectors shall be provided, both at the inlet and the outlet, at the primary and at the secondary water side of the heat exchanger.

Differential pressure switches between inlet and outlet on both sides of the heat exchanger with visual indication and potential free electrical contacts for alarm purposes shall also be installed.

The location of the heat exchangers shall be chosen in a way to allow easy maintenance and cleaning work. Related lifting equipment to dismantle the plates shall be provided by the Contractor for each heat exchanger.

20.3.2 Automatic self-cleaning filter

The primary loop of the cooling water systems of the PSPP Manara shall be provided with automatic self-flushing filter with mash of 300 microns or less shall be before the heat exchangers. For back-flushing of the filters, the back flushing pipe shall be connected directly to the drainage system of the power cavern.

The location of the filters shall be chosen in a way to allow easy maintenance and cleaning work.

Above the filters a monorail crane shall be provided by the Contractor for service and maintenance works of each filter. The piping design shall be done accordingly. That is to say no pipes shall hinder the lifting out process of the filters or maintenance works.

All material in contact with the water throughout shall be corrosion resistant suitable for the prevailing water conditions.

20.3.3 Pumps

The raw water pumps in the primary circuit and the circulating pumps in the secondary circuit shall be horizontal centrifugal type pumps. The pumps as well as the other equipment of the cooling water systems will be installed at 3 in the related cooling water room.

The speed of pumps shall not be more than 1450/1500 rpm. Generally horizontal centrifugal pump bearing shall be oil/grease lubricated as per pump manufacturers standard.

The suction strainer of raw water pumps shall be bronze or brass.

All pumps shall be equipped with a frequency converter in order to allow to regulate the pump in the common operation range.

Flow indicators with two potential free contacts for remote indication for alarm and start blocking shall be provided for water flow for each pump.

Shut-off valves and check valves shall be provided to allow disconnection and switching of each pump without emptying pipes.

20.3.4 Valves

Note: All valves shall have the same nominal diameter as the pipes in which they are installed.

All valves need to be accessible for the operation personal. If valves are in not accessible, steps, ladders and operation platforms shall be installed by the Contractor. All valves that need to be closed/opened under operation conditions (water flowing), an technical appropriate valve type needs to be chosen for safe and easy operation

20.3.4.1 Manually operated valves

a) For nominal diameters up to and including 200 mm i.d.:

These are conventional gate valves or butterfly valves with removable hand-wheels and „open“ and „closed“ position indicators. Provisions shall be made for the possible installation of contacts for the signal transmission of the valve position.

b) For nominal diameters more than 200 mm i.d.:

These valves are either butterfly valves or ball valves with removable hand wheels and continuous position indicators between „open“ and „closed“ positions. Provisions shall be made for the possible installation of contacts for the signal transmission of the „open“ and „closed“ positions.

20.3.4.2 Check valves

The check valves installed on each discharge pipe are of the clearway swing type with counter-weight so designed as to permit erection in any position. If the function is guaranteed check valves without counterweights can also be used.

20.3.4.3 Motor Operated Valves

They shall be remote controlled from respective unit control boards and the control room. Their „open“ and „closed“ position shall be transmitted to the unit control boards.

20.3.5 Piping

All pipes for the primary loop (open loop) shall be stainless steel with union joints, supports and all necessary fittings in non ferrous, non corrodible metal.

All pipes for the secondary loop (closed loop) shall be made of steel piping P235TR2 or similar grade. All pipes that are embedded in concrete shall be protected against plugging during the construction phase. Further there shall be no screwed flange connections inside the concrete, that means that all pipe connections of the cooling water system inside the concrete have to be of welded type.

For the pipe system a sufficient amount of flanges for dismantling shall be foreseen.

The use of welded pipes (longitudinal welded) pipe up to PN16 is possible.

All pipes shall be made exclusively of seamless steel tubes, grade DIN EN 10220.

20.3.6 Elbows

The elbows used shall, whenever possible, be standard elbows having R = 1,5D.

Whenever possible the supplier shall refrain from bending straight tubes. For the larger dimensions, the elbows can be made up of tapered strakes welded together, with not less than 3 strakes for 90° angle.

20.3.7 Dismantling joints

For every component/equipment (valves, compensators,…) part that is installed in the pipe a state of the art dismantling joint shall be provided in order to allow a dismantling of the built-in part at a later stage. The dismantling joint shall fit to the connected pipe in diameter, pressure resistance and material grade. During the detail design phase the arrangement of the dismantling joints will be defined.

20.3.8 Compensators/Expansion joints

In order to have a clear specific pipe system compensators and expansion joints shall be installed according to the static pipe calculation by the Contractor. The compensators shall be of rubber type and shall include built-in tie rods for axial movement limitation (tension limiter). Such compensators shall be also foreseen in pipe parts that cross main civil dilatation joints such as unit block joints and connections to moving or vibrating machine parts such as the penstock, pumps or the main units.

20.3.9 Pipe Supports

All pipes shall be fixed with a state of the art pipe support system. The supports shall be calculated according pipe calculation by the Contractor and should include all external influences such as vibrations, water hammer effects and the accessibility. All support parts that are not standard components (such as screws…) must be hot galvanized.

20.3.10 Drain Valves

The main supply pipes as well as the discharge pipes have to be provided with 1“ i.d. drain valves at appropriate spots. These valves are followed by permanent pipes connecting to the closest drainage system of the power cavern.

20.3.11 Protection against Corrosion and Tests

20.3.11.1 Protection against Corrosion

a) Piping embedded in concrete

Pipes embedded in concrete shall be minimized. All pipe section necessary to be embedded in concrete must be hot galvanized and must have a flange connection on each end. Welding after the galvanizing process and flange connection embedded in concrete are not allowed.

b) Visible piping

The whole of the visible piping, after assembly and testing of the welds, shall be hot galvanized. All necessary precautions shall be taken to prevent distortion of the pipes during the galvanization process. They shall all be thermally insulated to prevent moisture condensation on the pipes.

c) Standard equipment

The valves, check-valves and other standard equipment included in the piping system are normally delivered with an adequate protection against corrosion.

If not, they shall be protected internally and externally with two coatings of paint and, eventually, with a third coating of colored paint conforming with the color scheme adopted showing the purpose of the various pipes.

20.3.11.2 Tests

All tests of the system shall be executed according to EN 13480-5.

20.3.12 Tools and Equipment

The Contractor of the cooling water system shall supply a complete set of tools and equipment required for dismantling and reassembling any part of the cooling water system as well as the necessary tools and devices for adjusting the check-valves.

20.3.13 Local Control Board

The local control boards shall contain all the necessary relays, switches, signal lamps, instruments, safety devices, terminal blocks and the whole internal wiring. They shall be dust and moist proof, lockable and be of steel construction.

20.3.14 Control and Distribution Board

Control and supervision of the cooling water system shall be integrated in the Control and Monitoring System described and has to be coordinated with the contractor of the control system.

Additional for each cooling water system a local control, supervision and indication panel for the twin circuit cooling water and shaft sealing water systems shall be installed. Following local controls and indications shall be provided as a minimum:

- Remote/local selector switch
- Start/stop push buttons
- Pump selector switch
- Running time counter for each pump
- Emergency stop push button switch
- Alarm indications

The distribution board (containing the pump-motor feeders, etc.) of the cooling water system shall be combined with the local control panel. All actors and sensors of the cooling water system, including the components supplied with the motor generator and pump turbines shall be connected to these distribution board / control panel.

The control and distribution board shall correspond to the specifications and the requirements of the General Technical Specifications.

20.4 Tests

20.4.1 Workshop Tests

The equipment shall be type and routine tested in the manufacturer workshop as per relevant standards. All coolers and heat exchangers shall be pressure tested at 1.5 times the design pressure.

20.4.2 Site Tests

After installation the complete systems shall be pressure tested at 1.5 times the design pressure. The system shall maintain the test pressure for 2 hours without any sign of pressure loss.

The complete systems shall be tested for correct operation, indication and function of protection devices. Insulation resistance measurements as per relevant IEC standards shall be performed.

A simultaneous shut down test of all pumps with measurement of the water hammer shall prove that the design pressure is not exceeded.

If any of the test shall show deviations or unexpected results the Contractor shall take adequate measures at his own expenses to eliminate all issues as soon as possible.

20.5 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

20.6 Documentation

20.6.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

20.6.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for piping and equipment	Design Drawing	3
Foundation loads	Design Drawing	3

Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Operation instruction and maintenance handbooks	Technical Report	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10

21 DRAINAGE AND DEWATERING SYSTEM

21.1 General Description

In order to keep the power cavern of PSPP Manara project water free and for the dewatering of the waterways and the unit itself, the PSPP shall be equipped with a drainage and dewatering system. Moreover the drainage and dewatering system of the power cavern shall minimize the risk / limit the consequence of a flood inside the building caused by any failure in the water ways or the auxiliary systems using water.

The different waters shall be collected in the drainage and dewatering sump pit which is located at the lowest point of the power cavern. Inside the pit, pumps shall be installed, transferring the collected water to the service water tank which is located inside the surge tank at the low pressure part of the power water way. Further there shall be also the possibility to lead the water directly into the lower reservoir through an separate pipeline like shown in the drainage and dewatering system scheme with the drawing number MANARA/BD/05/0001.

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the drainage and dewatering system needed to keep the power cavern of Manara project water free. The contractor guarantees a perfect operation of the system and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, piping, wiring, etc. which is needed for the correct operation of the drainage as well as of the dewatering system.

Calculations needed for a state of the art system shall be done by the Contractor and forwarded to the Owner for approval. All components and sub-components of the systems have to be in accordance with the latest standards and safety regulations. All drawings needed for the correct installation of the drainage as well as of the dewatering system and the drawings needed for the design of the civil part of the power cavern and the power water way are in the scope of the Contractor.

The whole equipment installed inside the power cavern shall be shown in detail at the drawings and have to be mentioned at the part lists of the drawings.

The work for installing, manufacturing erection and commissioning of the different systems is included in the supply of the Contractor. Further the scope includes the block-out design for openings in concrete structure, auxiliary constructions for erection of equipment as well as the transport of the whole equipment to side and storage at side. The routing and block-out design shall be coordinated with the civil design.

The different systems which have to be installed at the plant shall be supplied complete, with all necessary components for its perfect performance and perfect operation even if it is not specifically mentioned here.

In general, the scope of supply of the Contractor comprises all pipelines needed for the drainage and dewatering system of the whole equipment which is installed inside the building of the power cavern. The dewatering system of the cavern consist of following components in general:

- Balancing pipe
- Dewatering pipes of the upstream side (Spiral case und Penstock)
- Dewatering pipes of the downstream side (draft tube)
- Collecting pipe leading to the drainage and dewatering sump pit

21.2 Performance Requirements

Following design conditions are the basis for the drainage and dewatering system:

Drainage system:

- Mountain/seepage water : < 40 m³/h
- Drainage of unit components (shaft seal…): < 20 m³/h

These above values are minimum values and need to be updated in the detail design stage according Contractors data. That is to say the system shall fulfil at minimum above values but shall be increased if required at the later project phase.

Dewatering system:

- Emergency event through breaching of a DN100 MIV bypass pipe at full supply level of the upper reservoir
- Dewatering of the high pressure power water way ~6500 m³ in <15 h
- Dewatering of the lower pressure power water way ~17500 m³ in <15 h

21.3 Design Conditions

Due to the given topology of the project there is no gravity drainage or dewatering possible for the cavern of the PSPP Manara.

Therefore a combined drainage and dewatering system is needed for the cavern as described hereafter. The system functionality is also shown in the drainage and dewatering system scheme with the drawing number MANARA/BD/05/0001.

The drainage and dewatering system includes following pipes:

Pipe Nr.	Pipe name	Pipe dimension
1	Drainage system power cavern included piping system shown in sheet 2 and embedded in concrete	DN200/PN2.5 Various dimensions
2	Drainage unit components	to be defined
3	Dewatering penstock	DN150/PN100
4	Common drainage pipe	DN250/PN10
5	Connection to firefighting reservoir	DN250/PN10
6	Dewatering to portal pipe	DN600/PN10
7	Dewatering draft tube	DN200/PN16
8	Dewatering cooling water system	to be defined
9	Filling pipe	DN100/PN100

All dimensions and pressure values stated above and on the schematic are preliminary and seen as minimum requirement. If necessary they need to be updated/revised according the detail design of the system components.

21.3.1 Drainage System and Drainage Pumps

All leakage of water inside the cavern will be collected by floor drains and a common piping system. Further all drainage water will be directed over a sludge sump, an oil separator into the main drainage and dewatering sump pit which is installed at the lowest elevation of the power cavern. Mountain/seepage water that is coming from the surrounding of the power cavern is collected in open drainage gutters and directed through the common piping system into the drainage sump pit. As for now a maximum value of 40 m³/h has been assumed, depending on the geology and situation on site the pump capacity of the drainage pumps need to be revised accordingly.

Drainage pumps	
Number of pumps	2
Design discharge per pump	60 m³/h
Head	appr. 95 m
Capacity per pump	appr. 25 kW

One drainage pump is designed to discharge 100 % of the assumed inflow whereas the second pump is 100 % redundant. In normal operation one pump pumps the continuous incoming water to the firefighting tank which is a part of the surge tank.

The oil separator shall be a filter less high performance separator in a compact design. It should include density independent inflow lock and an automatic oil withdrawal into a separate oil container. Its minimum nominal capacity shall be 20 l/s.

21.3.2 Dewatering System and Dewatering Pumps

In order to dewater the high pressure and low pressure side of the power water way a dewatering system shall be foreseen and connected with the sump pit which will located at the lowest point of the cavern.

There are three main dewatering pumps with a total capacity of 2500 m³/h foreseen. Main design criteria for the pumps is:

Emergency load case: failure of a MIV bypass pipe with an inner diameter of 100 mm at full supply level of the upper reservoir. Calculated with an average flow coefficient of 0.63 this leads to a maximum inflow of 2500 m³/h. In case of the emergency all three pumps need to be capable to discharge the incoming water.

The functionality of this system will ensure safety to personnel and will reduce the risks due to the consequences of a flooding incident.

Furthermore the dewatering pumps need to dewater following parts of the power water way under 15 hours.

- Dewatering of the high pressure power water way ~6500 m³ in appr. 5 h
- Dewatering of the lower pressure power water way ~17500 m³ in appr. 13 h

Dewatering pumps	
Number of pumps	3
Design discharge per pump	835 m³/h
Head	appr. 85 m
Capacity per pump	appr. 350 kW

In order to reduce the water hammer in the pipes appropriate expansion tanks shall be provided by the Contractor.

21.4 Equipment Particulars

21.4.1 Pumps

All pumps shall be selected in order to efficiently meet the flow and head requirements stated above.

The speed of pumps shall not be more than 1450/1500 rpm.

All pumps shall be equipped with a frequency converter in order to allow to regulate the pump in the common operation range.

Flow indicators with two potential free contacts for remote indication for alarm and start blocking shall be provided for water flow for each pump.

Shut-off valves and check valves shall be provided to allow disconnection and switching of each pump without emptying pipes.

21.4.2 Valves

Note: All valves shall have the same nominal diameter as the pipes in which they are installed.

All valves need to be accessible for the operation personal. If valves are in not accessible, steps, ladders and operation platforms shall be installed by the Contractor. All valves that need to be closed/opened under operation conditions (water flowing), an technical appropriate valve type needs to be chosen for safe and easy operation

21.4.2.1 Manually operated valves

a) For nominal diameters up to and including 200 mm i.d.:

These are conventional gate valves or butterfly valves with removable hand-wheels and „open“ and „closed“ position indicators. Provisions shall be made for the possible installation of contacts for the signal transmission of the valve position.

b) For nominal diameters more than 200 mm i.d.:

These valves are either butterfly valves or ball valves with removable hand wheels and continuous position indicators between „open“ and „closed“ positions. Provisions shall be made for the possible installation of contacts for the signal transmission of the „open“ and „closed“ positions.

21.4.2.2 Check valves

The check valves installed on each discharge pipe are of the clearway swing type with counter-weight so designed as to permit erection in any position.

21.4.2.3 Motor Operated Valves

They shall be remote controlled from respective unit control boards and the control room. Their „open“ and „closed“ position shall be transmitted to the unit control boards.

21.4.3 Piping

All pipes shall be made of steel piping P235TR2 or similar grade. All pipes that are embedded in concrete shall be protected against plugging during the construction phase.

All pipes shall be made exclusively of seamless steel tubes, grade DIN EN 10220.

21.4.4 Elbows

The elbows used shall, whenever possible, be standard elbows having R = 1,5D.

Whenever possible the supplier shall refrain from bending straight tubes. For the larger dimensions, the elbows can be made up of tapered strakes welded together, with not less than 3 strakes for 90° angle.

21.4.5 Dismantling joints

For every component/equipment (valves, compensators,…) part that is installed in the pipe a state of the art dismantling joint shall be provided in order to allow a dismantling of the built-in part at a later stage. The dismantling joint shall fit to the connected pipe in diameter, pressure resistance and material grade.

21.4.6 Compensators/Expansion joints

In order to have a clear specific pipe system compensators and expansion joints shall be installed according to the static pipe calculation by the Contractor. The compensators shall be of the rubber compensator type and shall include built-in tie rods for axial movement limitation (tension limiter). Such compensators shall be also foreseen in pipe parts that cross main civil dilatation joints such as unit block joints and connections to moving or vibrating machine parts such as the penstock, pumps or the main unit.

21.4.7 Pipe Supports

All pipes shall be fixed with a state of the art pipe support system. The supports shall be calculated according pipe calculation by the Contractor and should include all external influences such as vibrations, water hammer effects and the accessibility. All support parts that are not standard components (such as screws…) must be hot galvanized.

21.4.8 Drain Valves

The main supply pipes as well as the discharge pipes have to be provided with 1“ i.d. drain valves at appropriate spots. These valves are followed by permanent pipes connecting to the closest drainage system of the powerhouse.

21.4.9 Protection against Corrosion and Tests

21.4.9.1 Protection against Corrosion

a) Piping embedded in concrete

Pipes embedded in concrete shall be minimized. All pipe section necessary to be embedded in concrete must be hot galvanized and must have a flange connection on each end. Welding after the galvanizing process and flange connection embedded in concrete are not allowed.

b) Visible piping

The whole of the visible piping, after assembly and testing of the welds, shall be hot galvanized. All necessary precautions shall be taken to prevent distortion of the pipes during the galvanization process. They shall all be thermally insulated to prevent moisture condensation on the pipes.

c) Standard equipment

The valves, check-valves and other standard equipment included in the piping system are normally delivered with an adequate protection against corrosion.

If not, they shall be protected internally and externally with two coatings of paint and, eventually, with a third coating of colored paint conforming with the color scheme adopted showing the purpose of the various pipes.

21.4.9.2 Tests

All tests of the system shall be executed according to EN 13480-5.

21.4.10 Tools and Equipment

The Contractor of the drainage and dewatering system shall supply a complete set of tools and equipment required for dismantling and reassembling any part of the cooling water system as well as the necessary tools and devices for adjusting the check-valves.

21.4.11 Local Control Board

The local control boards shall contain all the necessary relays, switches, signal lamps, instruments, safety devices, terminal blocks and the whole internal wiring. They shall be dust and moist proof, lockable and be of steel construction.

21.4.12 Control and Distribution Board

Control and supervision of the drainage and dewatering system shall be integrated in the Control and Monitoring System described and has to be coordinated with the contractor of the control system.

Additional for each system a local control, supervision and indication panel for the drainage and dewatering systems shall be installed. Following local controls and indications shall be provided as a minimum:

- Remote/local selector switch
- Start/stop push buttons
- Pump selector switch
- Running time counter for each pump
- Emergency stop push button switch
- Alarm indications

The distribution board (containing the pump-motor feeders, etc.) of the drainage and dewatering system shall be combined with the local control panel. All actors and sensors of the system, including the components supplied with the MIVs and pumpturbines shall be connected to these distribution board / control panel.

The control and distribution board shall correspond to the specifications and the requirements of the General Technical Specifications.

21.5 Tests

21.5.1 Workshop Tests

The equipment shall be type and routine tested in the manufacturer workshop as per relevant standards. All equipment shall be pressure tested at 1.5 times the design pressure.

21.5.2 Site Tests

After installation the complete systems shall be pressure tested at 1.5 times the design pressure. The system shall maintain the test pressure for 2 hours without any sign of pressure loss.

The complete systems shall be tested for correct operation, indication and function of protection devices. Insulation resistance measurements as per relevant IEC standards shall be performed.

A simultaneous shut down test of all pumps with measurement of the water hammer shall prove that the design pressure is not exceeded.

If any of the test shall show deviations or unexpected results the Contractor shall take adequate measures at his own expenses to eliminate all issues as soon as possible.

The ready to operate system shall be tested in order to prove the performance requirements. All required measurement equipment such as flow meters, sensors etc. shall be provided by the Contractor. In addition starting the pumps with the diesel generator shall be tested simulating a power cut off.

21.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

21.7 Documentation

21.7.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

21.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for piping and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6

Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Operation instruction and maintenance handbooks	Technical Report	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10

22 COMPRESSED AIR SYSTEM

The power cavern of PSPP Manara shall be equipped with two compressed air systems, guaranteeing the compressed air supply of the equipment installed in the cavern. The working pressures for the two systems are defined as 70 bars for the high pressure system and 10 bar for the low pressure system.

22.1 High Pressure Compressed Air System

22.1.1 General Description

The unit compressed air system shall supply compressed air at a working pressure of 70 bar for the blow-out air tank (for synchronous condenser operation and pump start) and shall also supply compressed air at a working pressure of 10 bar for the operation generator air brake and the maintenance seal for the turbine. Optionally the generator air brake and the maintenance seal of the turbine could be supplied with compressed air out of the low pressure compressed air system. In that case, the capacity of the low pressure compressed air system has to be increased accordingly.

The equipment includes air compressors, air receivers, air dryer, piping, valves, accessories and all other materials and equipment to make the system complete and ready for operation.

The high pressure compressed air system is schematically shown in drawing MANARA/BD/MD/05/004.

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the high pressure air system needed for the supply of the one (1) hydroelectric power generating unit of the Manara project. The contractor guarantees a perfect operation of the system and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, piping, wiring, etc. which is needed for the correct operation of the high pressure system.

22.1.2 Design Conditions

In the system, the compressed air shall be produced by motor driven compressors located in the compressed air system room at Level 3 of the power cavern. The compressors shall be of water cooled type and will be supplied with cooling water out of the secondary loop of the cooling water system which is also shown on the high pressure compressed air system scheme MANARA/BD/MD/05/004.

The compressors are mounted in parallel and discharge in a common bus-pipe which lead the compressed air onto an air dryer unit. From there the compressed air is stored in the main air receiver with an capacity of 7000 litres.

In the unit compressed air system the compressors are started and stopped by manostats (for pressure monitoring) which automatically control the pressure in the tank/receiver. An automatic change-over switch controls the alternate operation of the compressors of each system.

The compressed air system shall supply the following equipment:

- Blow out system for the pump turbine
- Generator breaking system for the power generation unit

The blow out system of the turbines shall be controlled with level switches which are mounted at the draft tube of the unit.

For the supply of the generator braking systems of the PSPP Manara, the compressed air system shall be equipped with a pressure reducing unit which is charging one (1) air receiver with a pressure of 10 bar. This pressure receiver shall be located near the motor generator.

The water depression system shall be designed to blow down the units when the lower reservoir is at full supply level.

The general technical data of the high pressure compressed air system is listed below:

High pressure compressor and receiver data	
Nominal pressure in the system	70 bar
Minimum pressure in the system	60 bar
Number of blow out cycles without recharging	3
Raise pressure inside the air tanks from 60 bar to 70 bar	< 1 h
Raise pressure of the air tanks from 0 bar to 70 bar	< 3 h
Cooling system	Water cooled
Type	Piston compressor
Compressor capacity approx.	~2 x 22 kW
Flow rate approx.	min. 2 x 1300 l/min
Receiver volume	min. 1 x 7000 l
Nominal pressure for braking system	10 bar

Further the main air receiver shall be supplied with a 100 l condensate tank which has also to be provided by the Contractor including all necessary tank equipment. The size of the air tanks stated above and on the schematics shall be seen as minimum values. The Contractor shall update the values according to the detail design of all components.

22.1.3 Equipment Particulars

22.1.3.1 Compressors Characteristics

Characteristics	
Type	Piston type compressor
Number of cylinder	4
Cooling system	water cooled
Required pressure at the outlet	70 bar
Design capacity at aspiration/unit approx.	1300 l/min

22.1.3.2 Air Receivers

The air receivers shall be of welded design to withstand the test pressure for 1.5 times the operating (or nominal) pressure indicated on the drawing. The capacities of the air receivers will be designed with respect to the consumers requirements. The air receivers shall be equipped with a suitable pressure gauge, safety valve and a drain.

22.1.3.3 Air Dryer

If necessary and reasonable, an air dryer system shall be furnished. The air dryer shall have sufficient capacity to lower the temperature of the compressed air to 20° C when the compressor intake temperature is 35° C. A suitable air dryer system shall be supplied. In case of a tube type air dryer, the tubes shall be of copper or copper nickel alloy be adequately sized. The separator shall be designed to remove and hold the entrained moisture and oil. A drain connection shall be provided with the separator.

22.1.3.4 Piping

Piping for high pressure system shall be stainless steel with union joints, supports and all necessary fittings in non ferrous, non corrodible metal. Steel piping shall be used for general air service system. Pipe sizes shall be suitable dimensioned.

22.1.3.5 Auxiliary Equipment

<u>Valves:</u>

The stop valves, take-off valves and all service valves are conventional gate valves having the diameter of the pipes to which they are connected and shall be designed for PN100. Outlet valves for connection of auxiliary equipment shall be of the ball type for making the connection to the consumers if necessary.

<u>Check Valves:</u>

Check valves shall be provided as shown on the drawing to prevent back flow. Check valves shall be designed for a pressure of PN100 or high pressure system.

Pressure reducer:

If generator breaking system as well as the maintenance seal of the turbine will be fed by the high pressure compressed air system of the power cavern, a pressure reducing unit and low pressure compressed air tank has to be provide. The high pressure compressed air will be lead through an piping system directly to the pressure reducing units. The pressure reducing valves shall be executed in redundant type as shown in schematic drawing of high pressure compressed air system MANARA/BD/MD/05/004.

The pressure reducing units of the high pressure compressed air system shall reduce pressure of the compressed air system from 70 bars to 10 bars and storage the air directly in its own compressed air tank with sustainable capacity. The compressed air tanks for the 10 bar compressed air for the maintenance seal and the generator breaking system of the turbine shall be installed near the turbine governors.

The relevant pressure of the compressed air and the needed capacity of the air tanks for the supply of the generator brake systems and also for the maintenance seals of the turbine have to be coordinated with the generator and turbine supplier.

Blow-off valve:

Each main pipe shall be provided at its extremity with a blow off valve with expansion pot for draining purposes. In the high pressure system, this type of valve also operates as a safety pressure valve.

22.1.3.6 Manostats for Automatic Control

The manostats installed on the air receiver shall have the following switches for the operation:

Start up of the compressor:	by min 65 bar
Stop of the compressor:	by 70 bar
Start up of the 2nd compressor:	by 60 bar
with signalization at the control room	
General alarm at the control room:	at 55 bar

22.1.3.7 Motors

Motors of the compressors shall be class IP 44 or better squirrel cage induction type and shall be suitable for 400 Volt, 3 phase, 50 Hz operation.

22.1.3.8 Local Control Board

The local control boards shall contain all the necessary relays, switches, signal lamps, instruments, safety devices, terminal blocks and the whole internal wiring. They shall be dust and moist proof, lockable and be of steel construction.

22.1.3.9 Control and Distribution Board

Control and supervision of the high pressure compressed air system shall be integrated in the Control and Monitoring System described and has to be coordinated with the contractor of the control system.

Additional for each system a local control, supervision and indication panel for the system shall be installed. Following local controls and indications shall be provided as a minimum:

- Remote/local selector switch
- Start/stop push buttons
- Compressor selector switch
- Running time counter for each compressor
- Emergency stop push button switch
- Alarm indications

The distribution board (containing the motor feeders, etc.) of the compressed air system shall be combined with the local control panel. All actors and sensors of the system, including the components supplied with the pumpturbines shall be connected to these distribution board / control panel.

The control and distribution board shall correspond to the specifications and the requirements of the General Technical Specifications.

22.1.4 Tests

22.1.4.1 Workshop Tests

The equipment shall be type and routine tested in the manufacturer workshop as per relevant standards. All pipes and valves shall be pressure tested at 1.5 times the design pressure.

22.1.4.2 Site Tests

After installation the complete systems shall be pressure tested at 1.5 times the design pressure. The system shall maintain the test pressure for 2 hours without any sign of pressure loss.

The complete systems shall be tested for correct operation, indication and function of protection devices. Insulation resistance measurements as per relevant IEC standards shall be performed.

A blow down test with the required sequence (3 depressions and recharging time) with measurements of the water depression levels shall prove that the design parameters are fulfilled.

If any of the test shall show deviations or unexpected results the Contractor shall take adequate measures at his own expenses to eliminate all issues as soon as possible.

22.2 Low Pressure Compressed Air System

22.2.1 General Description

The power cavern shall be supplied with its own low pressure compressed air system.

The compressed air system of the power plant, which is situated at the compressed air room of the building at level 3, shall be responsible for the supply of the different floors and rooms of the power cavern like the electrical and mechanical workshop of the power cavern with pressurized air at a working pressure of 10 bars.

Further the low compressed air system is responsible for the supply of bus ducts of the unit. To keep the conductors of the motor-generator bus ducts dust-free, the unit of the power cavern will be equipped with its own air tank. The tank itself shall have a capacity from 1500 l at an operating pressure of at least 10 bar. After the tank, the low pressure air system will be equipped with a pressure reducing unit which is reducing the pressure from 10 bar to approximately 1.3 bar to supply the generator bus duct of the power plant.

For the production of the low compressed air, the power cavern will be equipped with two (2) low compressed air units which shall be of standard industrial type. Each compressor shall be equipped with its own air tank with a capacity of 270 l each. The compressors itself shall be of air cooled type and shall provide compressed air to the consumers of the power cavern. The provided compressed air shall be oil and dust free. The needed air velocity per hour for the supply of the compressor as well as the needed minimum air amount for cooling of the compressor has to be coordinated with all related suppliers.

The equipment includes air compressors, air receivers, air dryer, piping, valves, accessories and all other materials and equipment to make the system complete and ready for operation.

The system in detail is schematically shown in drawing MANARA/BD/MD/05/005.

Following spaces shall be supplied with compressed air with a pressure of 10 bar in accordance to low compressed air scheme:

- Inlet Valve Floor
- Turbine Floor
- Generator Floor
- Mechanical Workshop
- Electrical Workshop
- Machine Hall

Following spaces shall be supplied with compressed air with a pressure of approximately 1.3 bar in accordance to scheme MANARA/BD/MD/05/005:

- Motor-Generator Busduct Unit

Optionally the generator air brake and the maintenance seal of the turbine could be supplied with compressed air out of the low pressure compressed air system. In that case, the capacity of the low pressure compressed air system has to be increased accordingly. The tanks which are needed for the supply of the additional systems has to be installed near the governors. That means, that the 10 bar system of the low pressure compressed air system shall also supply:

- Generator air brake system
- Turbine maintenance seal

22.2.2 Scope of supply

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the low pressure air system needed for the supply of the one (1) hydroelectric power generating unit of PSPP Manara. The contractor guarantees a perfect operation of the system and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, piping, wiring, etc. which is needed for the correct operation of the low pressure compressed air system.

The scope of supply also comprises all needed supports, embedded parts, erection of embedded parts, piping, wiring, etc. which is needed for the correct operation of the following components and sub-components of the power plant:

- Compressor station with two (2) compressors and all accessories
- Two (2) main air receiver
- Two (2) compressed air receivers including all needed equipment for supplying of the generator IPB with compressed air
- Distribution circuits up to the various consumer points
- Control and distribution board

- The whole wiring and piping
- Optionally also the supply systems for the generator brake system and the turbine maintenance seal

Calculations needed for a state of the art system shall be done by the supplier and forwarded to the Owner for approval. All components and sub-components of the systems have to be in accordance with the latest standards and safety regulations. All drawings needed for the correct installation of the different systems and the drawings needed for the design of the civil part of the power cavern are in the scope of the contractor.

The whole equipment installed inside the power cavern shall be shown in detail at the drawings and have to be mentioned at the part lists of the drawings.

The work for installing, manufacturing erection and commissioning of the different systems is included in the supply of the contractor. Further the scope includes the block-out design for openings in concrete structure, auxiliary constructions for erection of equipment as well as the transport of the whole equipment to side and storage at side. The routing and block-out design shall be coordinated with the civil design.

The different systems which have to be installed at the plant shall be supplied complete, with all necessary components for its perfect performance and perfect operation even if it is not specifically mentioned here.

22.2.3 Control & Distribution Board for the Low Pressure Compressed Air System

The Control and Distribution Board of the low pressure compressed air system shall accommodate the control equipment, motor starters, protection equipment, provisions for local and remote alarm, wiring, etc.

The control equipment shall also include but not be limited to the following components:

- key operated selector switch, three positions, "Off", "Manual" and "Automatic"
- push buttons "On" and "Off" for both compressors
- indication lamps "On", "Off" and "Failure" for both compressors
- operating hour counters for both compressors
- manual selector switches for assigning the compressors as:
  - main duty
  - standby
- emergency stop push button switch
- collective alarm output
- interface to the power plant control and monitoring system

The control and distribution board shall correspond to the specifications of the control system and the requirements of the General Technical Specifications.

Connection interface for the power supply of the low pressure compressed air compressors is the low voltage distribution of the power cavern.

22.2.4 Tests

22.2.4.1 Workshop Tests

The equipment shall be type and routine tested in the manufacturer workshop as per relevant standards. All pipes and valves shall be pressure tested at 1.5 times the design pressure.

22.2.4.2 Site Tests

After installation the complete systems shall be pressure tested at 1.5 times the design pressure. The system shall maintain the test pressure for 2 hours without any sign of pressure loss.

The complete systems shall be tested for correct operation, indication and function of protection devices. Insulation resistance measurements as per relevant IEC standards shall be performed.

If any of the test shall show deviations or unexpected results the Contractor shall take adequate measures at his own expenses to eliminate all issues as soon as possible.

22.3 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

22.4 Documentation

22.4.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

22.4.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3

Installation drawings	Design Drawing	3
Block outs necessary for piping and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Operation instruction and maintenance handbooks	Technical Report	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10

23 FIRE PROTECTION, FIRE FIGHTING AND FIRE DETECTION SYSTEM

23.1 General Description

In general the power cavern, the access tunnel as well as the control building of the PSPP Manara are designed to avoid explosions and fire hazards.

Nevertheless if an event of fire will take place at one of the aforementioned buildings, a firefighting, fire protection and fire detection system shall be installed at the different areas to protect the buildings, equipment and personnel.

A fundamental fire safety assessment/study should at first be conducted by the contractor in conjunction with the layout of the building/s and its exterior together with the equipment foreseen to be installed, since there are statutory maximum distances people are allowed to walk in regard to a safe place of refuge and or safe passage to egress. During the assessment, potential fire loads should be identified and appropriate detection, alarm and suppression measures should be selected for that zone.

The firefighting system of the PSPP Manara shall be supplied completely with all necessary components and equipment which will be needed for safe operation of the power plant and shall also is in accordance with the latest standards and regulations.

All equipment which will be installed by the contractor have to be in accordance with the latest standards and safety requirements especially with the standards and requirements of NFPA, safety Eng., fire brigade and the National Standards.

The contractor is responsible for the perfect installation and operation of the firefighting equipment to safe life in case of fire even if not specifically mentioned in the following technical specification.

23.2 Scope of Supply

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the whole fire prevention, fire protection, fire detection and firefighting system and all needed equipment for the PSPP Manara project.

The contractor guarantees a perfect operation of the equipment and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, wiring, etc. which is needed for the correct operation.

Calculations needed for a state of the art system shall be done by the supplier and forwarded to the Owner for approval. The calculations which are prepared for the firefighting and fire detection system shall be summarized in a calculation report.

All components and sub-components of the fire detection and firefighting system of the HEPP have to be in accordance with the latest standards and safety regulations. All drawings needed for the correct installation and the drawings needed for the design of the civil part of the power cavern as well as of the control building and main access tunnel are in the scope of the contractor.

A safety engineer is responsible for writing a safety plan for the buildings, which has to be coordinated with the Israel fire brigade.

The Contractor shall coordinate the detail design of firefighting and emergency system and apply for approval by Israeli Fire brigade. Finally a integration function test together with all relevant building service supplier according to Israeli Fire brigade shall be held. Furthermore, a fire alarm has to be triggered and an evacuation exercise in coordination with the fire brigade.

The whole equipment installed inside and outside of the power cavern, the access tunnel and the control building shall be shown in detail at the drawings and have to be mentioned at the part lists of the drawings.

The work for installing, manufacturing erection and commissioning of the different systems is included in the supply of the contractor. Further the scope includes the block-out design for openings in concrete structure, auxiliary constructions for erection of equipment as well as the transport of the whole equipment to side and storage at side.

The routing and block-out design shall be coordinated with the civil design.

The equipment which has to be installed at the plant shall be supplied complete, with all necessary components for its perfect performance and perfect operation even if it is not specifically mentioned here.

All in all the supply comprises basically of the manufacturing, erection, commissioning and testing of the following equipment with all its components and sub-components for the power cavern, the access tunnel, the control building and the outdoor areas in accordance to the latest standards:

- The whole firefighting system
- The whole fire detection system
- The whole fire protection and fire prevention system

23.3 Specific Standards

The design, manufacturing, installation of the complete firefighting, fire protection, fire detection and alarm system shall be in accordance to the latest standards and safety regulations and UL 864 and I.S 1220 approved.

The design of the different systems have to be in accordance with the safety regulations and systems requirements based on the statute law in regard of fire safety systems.

If none exists then the NFPA standards especially NFPA 851 (Fire Protection of Hydroelectric Generating Plants) can be adopted.

23.4 Design description

23.4.1 General

The contractor of the firefighting system is responsible to install an adequate fire extinguishing system for each area and each room of the plant area. Before beginning with the detail design of the firefighting system, the contractor shall furnish a detailed schematic drawing showing all kinds of fire extinguishers which have to be approved by the Owner.

The fire extinguishers systems have to be in accordance to the latest standards and regulations like the NFPA as well as to comply these standards with the safety regulations and safety conditions of the Owner.

The contractor shall coordinate the agent of the extinguish systems with the suppliers of the electromechanical parts and equipment of the power plant, to ensure that each area and the personnel working inside and outside of the powerhouse is protected from fire in a correct way.

Main system cabling for firefighting, fire detection and alarm system shall be of type NXHYK-FE-180-E-30 or E-90 according to the latest national requirements.

Following components are estimated:

Power cavern / power house:

Fire hose cabinets	12 pcs
CO2 extinguisher (K5)	27 pcs
FOAM extinguisher (S9)	27 pcs
DRY CHEMICAL extinguisher trolley (P50)	2 pcs
FM 200 extinguishing systems for electrical rooms	17 pcs
Fire detection system	Automatic detector and push buttons whole area
Fire emergency mask	27 pcs

Access tunnel (main, flexible joint, surge tank, mucking tunnel, portal building):

Fire hose cabinets	10 pcs
FOAM extinguisher (S9)	10 pcs
Fire detection system	Push buttons at entrance areas and at fire hose cabinets, detector cable at high voltage cable route, automatic detector in portal building and electrical rooms (if required by fire brigade)
Fire emergency mask	20 pcs

Control building:

Fire hydrants installed at outdoor area	2 pc
Fire hose cabinets installed inside the powerhouse	2 pcs
Foam spray system for diesel generator room	1 pc
CO2 extinguisher (K5)	2 pcs
FOAM extinguisher (S9)	2 pcs
DRY CHEMICAL extinguisher trolley (P50)	1 pcs
FM 200 extinguishing systems for electrical rooms	1 pcs
Fire detection system	Automatic detector and push buttons whole area
Fire emergency mask	5 pcs

Upper and Lower Reservoir (operation, intake and bottom outlet buildings):

FOAM extinguisher (S9)	5 pcs
Fire detection system	Automatic detector in electrical rooms (if required)
Fire emergency mask	5 pcs

The given data, values and dimensions are preliminary type, based at the given basic design of the building structure and the equipment which is installed in it. The given data and values shall be revised by the contractor of the detail design of the firefighting system. All data have to be coordinated with the contractors of the other equipment as well as the contractor of the detail civil design.

23.4.2 Fire Prevention

23.4.2.1 FIRE AREA DETERMINATION.

The hydroelectric generating plant is subdivided into separate fire areas as determined by the fire risk evaluation for the purposes of limiting the spread of fire, protecting personnel, and limiting the resultant consequential damage to the plant. Fire areas should be separated from each other by approved fire barriers, spatial separation, or other approved means.

Determination of fire area boundaries should be based on consideration of the following: types, quantity, density, and locations of combustible material; location and configuration of plant equipment; consequences of losing plant equipment; location of fire detection and suppression systems; and personnel safety/exit requirements.

It is recommended that most fire barriers separating fire areas be of 2 hours fire resistance rating. If a fire area is defined as a detached structure, it should be separated from other structures by an appropriate distance.

23.4.2.2 FIRE DOORS, ESCAPE ROUTES AND OPENINGS IN FIRE BARRIERS

Location and material of fire doors and escape routes should comply with Israli Fire Regulation such as NFPA Standards. Exits must be of fire-rated construction.

All openings in fire barriers should be provided with fire door assemblies, fire dampers, penetration seals (fire stops), or other approved means having a fire protection rating consistent with the designated fire resistance rating of the barrier. Windows in fire barriers (e.g., control rooms or computer rooms) should be provided with a fire shutter or automatic water curtain. Penetration seals provided for electrical and piping openings should be listed or should meet the requirements for an “F” rating when tested in accordance with ASTM E 814, Fire Tests of Through-Penetration Fire Stops. Other test methods for qualifications of penetration seals, such as IEEE 634, Testing Fire Rated Penetration Seals, can be permitted to be considered for this application.

Fire door assemblies, fire dampers, and fire shutters used in 2-hour rated fire barriers should be rated not less than 11/2 hours.

23.4.2.3 BUILDING CONSTRUCTION MATERIALS

Building components for all structures of the power cavern, access tunnel and the control building and the subsurface structures of these buildings should be of non-combustible or limited combustible materials.

Roof coverings should be Class A in accordance with NFPA 256, Standard Methods of Fire Tests of Roof Coverings. Metal roof deck construction, where used, should be Class I listed or approved.

Cellular or foam plastic materials should not be used in interior finish in buildings critical to the generation processes or in subsurface structures.

Interior finish in buildings critical to power generation should be Class A.

Interior finish in buildings not critical to the generation processes should be Class A or Class B.

23.4.3 Water based Firefighting Systems

23.4.3.1 Hydrant system

The whole hydrant system for the power cavern, main access tunnel, control building and outer areas shall be a network of pipes that shall supply pressurized water to the different hydrant outlet valves.

Inside the power plant an adequate quantity of fire hose cabinets shall be installed, to ensure that all areas of each floor could be reached by a water based fire extinguishing system. Each cabinet shall be equipped with and fire hose reel with 30m of hose and single headed hydrant valve as well as a 6kg portable carbon dioxide cylinder.

The outdoor area of the plant shall also be equipped with fire hose reel trolleys that could be served with water out of the hydrant system and shall carry 40m of fire hose as a minimum.

The firefighting tank will be installed inside the surge tank of the downstream waterway at elevation 88.50 masl. The firefighting tank with a maximum capacity of 270 m^3 will continuously be supplied with water out of the drainage and dewatering system of the power cavern.

The water for the supply of the power cavern firefighting system will be transferred to the cavern through a separate pipe.

For the water supply of the hydrant system inside the access tunnel, a pipe with DN125 will lead from the power cavern (level 18.675 masl) in direction of the portal of the main access tunnel (level 79.30 masl).

The supplier of the firefighting system has to guarantee that fire extinguishing systems at the highest elevation will also be supplied with a pressure of at least 5.5 bar minimum. According NFPA14 the maximum allowable pressure for hose connections is stated with 6.9 bar. If pressure exceed 6.9 bar at the connection of hoses at lower floors a pressure regulating device shall be provided to limit the residual pressure according to NFPA 14.

In case the minimum pressure cannot be achieved adequate booster pumping units or emergency pumps shall be installed (e.g.at dewatering pumps at level 2, - 1.45 masl.)

To ensure that the water supply pipe which is leading from the surge tank to the pumps is not plugged by mud or other things, the pumps shall back-flush the pipe of the system periodically.

The water supply for the firefighting system of the control building shall be done by the local water supply. In case the pressure of the water storage at the surge tank does not reach the minimum requirements, a part of the main access tunnel could optionally be powered by local supply coming from the control building.

The firefighting system (spray water system) for the unit transformers and high voltage cable way for the main access tunnel is situated at level 7 shall be supplied with water out of firefighting system.

23.4.3.2 Spray water system for unit transformers and cable way main tunnel

The unit transformer shall be protected by an automatic high pressure water spray system (e.g. HI-FOG). The system must be capable to extinguish the transformer in case of emergency for spray duration of 30 minutes. The system shall be designed as a ring main network of projectors around unit transformer. The system shall be suitable for automatic operation as well as local manual control and remote control from the fire alarm and control panel in the central control room. The system contains of spray heads, tubing, valves, pumps unit, water storage tank, water supply and electrical power supply.

In addition to the transformer protection the near surrounding of the 161 kV high voltage cable tray system along the main access tunnel shall be protected. The system must be capable to cover duration of 30 minutes. The length of the cable way in the main access tunnel is around 1350 m. The system contains of spray heads and tubing above the cable systems along the tunnel, pump unit and water storage tank. For the electrical pump unit and water storage tank two rooms in the power cavern at level 7 are foreseen. The sprinkler heads are equipped with heat-activated glass bulbs which are individually open at around 141 °C.

23.4.4 Chemical, mobile and stationary firefighting systems

23.4.4.1 FM 200 Extinguishing Systems

To minimize the risk of damage in rooms with a large amount of electric and electronic equipment caused by a fire, a firefighting system shall be installed which is able to eliminate the fire as quick as possible.

Therefore a FM200 firefighting system shall be installed in these rooms which will be able to eliminate the fire in a short an effective way. Furthermore this kind of firefighting agent ensures, that no equipment which is installed in the respective rooms will be damaged by the agent itself during fire eliminating and the gaseous agent of the FM200 system is not harmful to personnel as well as for the environment.

Following rooms shall be equipped with an FM200 extinguishing system as a minimum:

Powerhouse / power cavern:

- Generator busduct and SFC rooms
- Medium voltage switchgear and station service transformer rooms
- Main Distribution Rooms 400V AC / 220V DC / 230 V AC UPS
- Telecom and metering rooms
- Unit controller and excitation rooms

Control building:

- Main Distribution Rooms 400V AC / 220V DC / 230 V AC UPS
- 22 kV Medium Voltage Switchgear

An odorant (lemon) must be added to the extinguishing gas.

23.4.4.2 Foam Fire Extinguish System

For protection of the diesel generator room in the control building a foam firefighting system shall be installed which shall take its source of water out of the local water supply.

If event of fire will take place in the respective room of the power plant, the foam firefighting system shall be activated automatically to protect the equipment which is installed as well as personnel inside. The activation of the firefighting system shall also be possible by manual push buttons near the doors of the diesel generator room.

The position of the foam tank has to be coordinated during the detail design phase with the civil designer.

All necessary components for the firefighting inside of the diesel generator room are in the scope of supply of the contractor.

In order to prevent the workers in case of an fire hazard inside the power cavern, the main access tunnel and the control building safety devices such as alarm devices shall be installed. Further organizational provisions have to be provided to minimize risks for the workers inside the different buildings of the power plant.

23.4.4.3 Portable chemical Firefighting Extinguishers

The contractor shall provide an adequate amount of portable and mobile hand operated fire extinguishers for interior mounting in the powerhouse as well as in the main access tunnel and control building.

As mentioned before, each fire hose cabinet shall be equipped with its own carbon dioxide cylinder.

Foam extinguisher shall be provided for areas like for example oil storages, area of governor oil system and other rooms with extremely flammable liquids.

The scope of supply shall contain all necessary equipment.

23.4.4.4 Mobile chemical Firefighting Extinguishers

To be able to eliminate fires inside the powerhouse or fires which could not be eliminated with the water firefighting system, mobile chemical fire extinguishers carried out as carbon dioxide and dry chemical fire extinguishers shall be provided at the machine hall level of the plant.

Therefore the contractor shall design and provide an adequate amount of mobile carbon dioxide extinguishers with a sufficient capacity and hose length as well as sufficient mobile dry chemical extinguishers. The design, capacities and hose lengths of the fire safety system is subject to the Owner’s approval.

23.4.5 Fire detection and alarm system

For the permanent supervision of the indoor and outdoor areas of the power plant, main access tunnel and control building a fire detection and alarm system shall be installed to ensure the protection of the equipment which is installed in the rooms and shall supply and install a state of the art system (full protection arrangement over all areas of the plant).

It is the supplier's responsibility to install the correct fire detection system as well as number and location of the detectors for the different areas of the plant. The start of the installation works may only take place after approval of the system by the owner of the project. All detectors which will be used shall not contain any moving part inside.

The different room of the buildings shall be equipped with optical detectors, ionization smoke detectors, and manual alarm push buttons. The fire detection and fire alarm system itself shall be an automatic early warning system.

The main access tunnel shall be equipped with a temperature rise alarm via a fibre optic cable to the control system which activates the water spray system above the high voltage cable systems.

The detector units as well as the manual alarm push buttons which shall be installed in the different areas of the fire detection system shall be connected directly to the fire alarm control unit of the plant.

The needed amount of the installed fire detectors and the type which will be installed at the different areas shall be in accordance to the expected fire phenomena. The installed detectors shall further be able to minimize false alarms and shall be immune to electromagnetic interferences.

Further different audible and visible alarm systems shall be installed inside and outside which are activated by the fire alarm and control unit and shall warn personnel as soon as possible.

Near the entrance of the power plant and at the main access tunnel entrance, a UKLL fire brigade panel according to the latest requirements shall be installed to give the fire brigade an overview of the situation in the plant as well as the rooms or area where the event of fire has occurred.

Adequate to the fire alarm control panel an distribution board for controlling of the water storage and its equipment shall be installed in the control room of the powerhouse as well as near to the entrance of the water storage building itself. Alarm panel shall supervise that the water sources and pumps are healthy; these health signals shall be derived from to the power plant control and monitoring system that receives the health status from the control panel/board responsible for operation of the pumps.

The control panel of the fire alarm system shall have a front door with acrylic visor. It shall be possible to have a complete view through all signaling and control devices, even when closed. The control unit shall be of fully electronic type. It shall be possible to remotely operate all important functions and to switch on and off any detector line at the control unit. The panel shall be equipped with a communication interface through a data network for the monitoring of all relevant information of the system.

The panel shall be intelligent, with a modular construction enabling future expansions, with addressable devices, 2-wire communication loop, detection points, supervision and control that are all individually identifiable. It shall be capable of processing the analogical signals from the detectors, as well as discrete or digital signals. The panel shall be able to generate complete reports for password-authorized accesses.

Each panel shall have the capacity of activating/interrogating each device that is connected to it and detect if the command/interrogation was not received by any of the devices and warn the operator, as a fault condition. The panels shall have dry tension-free individualized contacts, corresponding to abnormal and system status conditions available for the Supervisory Control and Data Acquisition (SCADA).

Additionally, the panels shall count with independent dry contacts for the actuation of the Ventilation System. These contacts shall be actuated to command the shutdown of the ventilators every time there is a fire alarm in the areas of the panels.

Every panel shall be provided with its own power supply. Further each control panel shall be supplied with its own emergency power supply carried out as battery system and the needed charging devices.

The fire dampers shall be closed automatically following the detection of fire, smoke or fume in the respective fire zones.

It is supposed that the fire brigade may require a dedicated communication and telephone land line for the fire system dailer in the operation building. Adequate communication equipment and capacity shall be considered.

Furthermore an emergency telephone shall be installed at each UKLL fire brigade panel to communicated to central point inside the power cavern.

The scope of the work under this contract comprises the complete design, manufacture, supply of materials and equipment, installation, testing and commissioning of the fire detection and fire-alarm system and its accessories and also the coordination with the HVAC supplier for the arrangement of fire-dampers in air ducts and walls in accordance with the considered fire zones.

For activation and deactivation of smoke extraction of the power cavern and main access tunnel, controlling the air ventilation system as well as fire dampers and fire doors in case of fire, announcing of alarms to the public address system and power plant control system, the contractors has to provide sufficient interfaces and coordination with the other system suppliers.

23.4.6 Fire protection

The contractor of the firefighting, fire protection and fire detection system is responsible for all means of protection which will be needed for a safe operation of the power cavern and the other buildings of the PSPP Manara.

The fire protection system of the different buildings shall be in accordance with the latest standards and requirements. The fire protection system of the buildings includes also the closing of the openings which are leading to other rooms. In every block out for cables in fire rating walls there shall be fire proof insulation and MCT blockage components.

The fire protected doors and windows which will be installed inside the buildings of Manara PSPP are not in supply of the contractor.

Size of openings and other issues which are influenced by the design of the fire protection system have to be coordinated with the suppliers of the equipment and the building technology.

23.5 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

The correct installation of all necessary fire protection systems and inclusive the needed certificates for the different systems has to be supplied by the contractor. Further all equipment which will be used for testing of the installed firefighting and fire protection system has to be presented to an state accredited test institute.

Factory Tests

Routine tests of each component, operational tests of monitoring panels, power supplies, detectors and alarm annunciators, etc. shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

After installation, the firefighting and fire detection system shall be field tested including operational tests, visual inspection of complete installations.

The complete systems shall be tested for correct operation, indication and function of protection devices as per relevant standards. Insulation resistance measurements as per relevant IEC standards shall be performed.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings

- Insulation measurement and pressure tests of the installations
- Function test of each detector
- Function test of overall system including interfaces to the other suppliers
- Function test of overall alarm and firefighting control system in the presence of the national fire brigade

23.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

23.7 Documentation

23.7.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

23.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6

Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Operation instruction and maintenance handbooks	Technical Report	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10

24 HVAC SYSTEM

24.1 General Description

The purpose of the Heating Ventilation and Air Conditioning (HVAC) system is to provide suitable conditions for human occupation, cooling of the various spaces where heat is dissipated, providing suitable ambient conditions for sensitive electronic equipment, avoidance of concentration of polluting or harmful substances and the provision of smoke and heat extraction in case of fire.

The cavern of the PSPP Manara will be equipped with its own heating, ventilation and air conditioning system which also comprises a fire smoke extraction system and an overpressure ventilation system. The system is responsible for the ventilation in case of fire, to guarantee smoke free escape routes inside the power cavern and the main access tunnel.

The fresh air supply for the power cavern will be provided through the escape corridor which is directly leading to the portal of the access tunnel of the power cavern. To guarantee smoke free escape route from the power cavern through the main access tunnel to the outer area, an smoke extraction unit have to be foreseen which is operating independent of the HVAC central air handling unit and shall be able to operate also in case of loss of the AC main power supply. In order to be able to transport the fire smoke inside the cavern to the outside, an smoke extraction channel is installed at the top of the access tunnel. This smoke extraction channel shall be directly coupled to the smoke extraction system of the power cavern to guarantee smoke free escape roots.

The fresh air supply for the main access tunnel will be via the fresh air channel – access tunnel and a fan situated at the portal of the main access tunnel. The smoke extraction will be accomplished with a sufficient number of jet fans in the main access tunnel. The suction of fresh air must be situated in a way that no smoke will sucked in.

The control building shall also be equipped with an HVAC system. The central air handling unit shall be carried out as a compact unit which shall act equal to the HVAC system of the power cavern. The central air handling unit can be installed outdoor on the roof of the building or indoor in adequate room.

24.2 Scope of Supply

The contractor guarantees a perfect operation of the equipment and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, wiring, etc. which is needed for the correct operation.

All in all the supply comprises basically of the manufacturing, erection, commissioning and testing of the following equipment with all its components and sub-components for the power cavern/power house, main access tunnel and control building:

- HVAC system

- VRV/VRF system
- Smoke extraction system and overpressure ventilation system

All components and sub-components of the HVAC system have to be in accordance with the latest standards and safety regulations.

All drawings needed for the correct installation and the drawings needed for the design of the civil part of the powerhouse are in the scope of the contractor.

The calculations which are prepared for the HVAC system shall be summarized in a calculation report. The outputs of the calculation as well as the given dimensions of the rooms, the air change rates, heating loads (including the inputs of the EM suppliers), the air velocities, etc. shall be outlined in a detailed room list to provide a good overview.

A detailed room list including data for ventilation, cooling and heating as well as the heating loads of the EM-suppliers (could also be included in the room list of the Central air handling unit) shall be prepared.

The calculations and reports shall be forwarded to the Owner for approval.

The whole equipment installed inside the power cavern, main access tunnel and control building shall be shown in detail at the drawings and have to be mentioned at the part lists of the drawings.

The work for installing, manufacturing erection and commissioning of the different systems is included in the supply of the contractor. Further the scope includes the block-out design for openings in concrete structure, auxiliary constructions for erection of equipment as well as the transport of the whole equipment to side and storage at side. The routing and block-out design shall be coordinated with the civil design.

The equipment which has to be installed at the plant shall be supplied complete, with all necessary components for its perfect performance and perfect operation even if it is not specifically mentioned here.

24.3 Climate Conditions

The HVAC system shall be able to provide suitable ambient conditions for human occupation, cooling of the various spaces where heat is dissipated, providing suitable ambient conditions for sensitive electronic equipment, avoidance of concentration of polluting or harmful substances.

Following outside air temperatures are given for the upper and lower reservoir area:

Location: Lower reservoir												
Temperature [°C]	1	2	3	4	5	6	7	8	9	10	11	12
Average max. daily	16.5	17.4	20.5	26.0	30.3	32.8	34.3	34.5	33.7	30.4	24.0	18.6
Maximum ever	27.0	27.8	31.7	37.8	43.3	43.0	44.5	42.5	43.6	39.5	34.2	29.9
Average min. daily	5.8	5.9	7.8	11.0	13.9	16.6	18.7	19.2	17.2	14.1	10.3	7.0
Minimum ever	-3.1	-3.6	-0.5	0.0	6.9	9.8	13.7	14.0	8.3	6.1	-1.0	-2.5
Location: Upper reservoir												
Temperature [°C]	1	2	3	4	5	6	7	8	9	10	11	12
Average max. daily	9.4	10.1	13.3	19.5	25.0	28.3	29.8	29.8	28.1	23.7	16.7	11.5
Maximum ever	21.7	21.2	24.2	32.4	38.1	38.0	39.0	38.7	36.8	33.1	27.5	24.4
Average min. daily	4.5	4.3	6.3	10.6	14.3	17.0	18.8	18.8	17.7	15.1	10.3	6.4
Minimum ever	-3.6	-6.5	-2.2	0.3	5.8	8.7	13.2	14.0	12.0	7.2	0.1	-2.7

24.3.1 General conditions

The Temperature inside the cavern shall not exceed more than +26°C and shall not fall below 18°C like written below.

Maximum ambient air temperature	+26 °C
Minimum ambient air temperature	+18 °C
Maximum outside air temperature for design	+40 °C
Minimum outside air temperature for design	0 °C
Altitude between	+736,00 masl to +0,00 masl

24.3.2 Indoor area ambient conditions for design

The following design values shall be used for equipment installed in switchgear rooms:

Minimum ambient temperature	+5 °C
Maximum ambient temperature, 24-hour period	+40 °C
Maximum ambient temperature, 4-hour (max.) period	+50 °C
Maximum relative humidity, short-term	90%
Normal relative humidity	30–70%
Maximum cooling water temperature:	+30°C (to be confirmed)
Minimum cooling water temperature:	+7°C (to be confirmed)

24.4 Standards

In general all components have to be in accordance with the latest standards and regulations, to guarantee save operation of the components and sub-components of the whole HVAC system.

The HVAC system shall consider to all regulations and safety requirements.

The different systems of the heating, ventilation and air conditioning system shall be in accordance to following regulations as a minimum:

EN 13779	Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems
EN 50272	Safety requirements for secondary batteries and Battery installations
EN 779	Particulate air filters for general ventilation – Determination of the filtration performance

NFPA standards

It is the contractor's responsibility to use the latest standards and safety regulations to guarantee a state of the art system and pleasant working conditions.

The ventilation system is part of the emergency evacuation system providing safe escape route to the power plant personnel and therefore the overall firefighting and emergency evacuation concept shall be coordinated and approved by the Israel Fire Brigade.

24.5 Design Particulars

24.5.1 General

The power cavern and the control building are equipped with its own central unit system.

The central air handling unit for supply of the power cavern with all its rooms and areas shall be installed at level, 10.625 masl.

The HVAC-room shall be equipped with floor drains for discharge of condensate as well as drainage in case of maintenance works of the air handling unit.

The fresh air from outside of the plant and buildings will be mixed with the recirculation air inside the mixing plenum, filtered, precooled, chilled for dehumidification, heated and brought into the supply air duct by the supply air fan.

All rooms in which air borne pollutants can occur (e.g. battery room, sanitary rooms, kitchen, etc.) will be supplied by fresh air derived from the main air-handling unit, the rooms shall be equipped with an appropriately rated extraction air fan and associated exhaust air ductwork that is led to the exterior by the main access tunnel.

The supply air, return air and the exhaust air ducts will be provided with fire dampers at each intersection within the boundary of a fire compartment.

In some rooms of the power plant, higher air velocities are needed caused by the equipment which is installed there like for example the compressors of the compressed air room. These special air velocities have to be coordinated by the contractor with the supplier of the mechanical and electrical components of the plant.

The rooms for the main transformer have to be provided with a ventilation system which is protected against an increase of pressure inside the room causes by a flashing arc. To prevent damaging of the supply and return air ducts by the event of a flashing arc, the ventilation of the main transformer rooms shall be carried out as indirect ventilation system via blast valves.

Especially in the control building, electrical rooms and other rooms with high heat disposal, cooling coils with circulation fan are foreseen in order to minimize main system dimensions. The condensing type air-conditioning units for the rooms of the power cavern and the control building shall be provided as VRV/VRF system (variable refrigerant volume/variable refrigerant flow system).

The supply also contains the external air conditioning units with the respective modules, air intake grilles, louvers, dampers, pressured dampers, filters, frequency inverters, position switches, supervision and control devices, Local Command Panels.

For guaranteeing the required air quality, sensors shall be added in the rooms measuring the humidity and the air temperature which are used for controlling of the main air handling unit.

In general all ducts of the system shall be rectangular ducts. Ducts which are inside of concrete shall be circular ducts. Rooting has to be approved and coordinated with the civil constructer to create a sustainable solution.

Based on the proposed design philosophy of the Contractor the ventilation system for supply, exhaust air and smoke extraction for the power cavern and access tunnel have to be carried out with following main items:

All necessary equipment needed for the correct operation, security of the power plant and controlling of the HVAC system shall be supplied by the contractor and installed in the power plant area.

The system shall be supplied complete, with all necessary components for its perfect performance, even if not specifically mentioned here, comprising basically of ventilators and exhausters, air intake grilles, louvers, dampers, pressured dampers, smoke detectors, filters, frequency inverters, position switches, supervision and control

24.5.2 Air Conditioning and Recirculating

The central air handling unit is responsible for air conditioning of all rooms of the plant. The return air of the rooms is collected in the return air ductwork of the power plant which directly leads to the air handling unit. In the air handling unit the return air is mixed with 15-40% fresh air and is also regulated in temperature and humidity.

After the conditioning in the air handling unit, the supply air is leaded to the supply air ductworks. The supply air ductworks are responsible for distributing the air in the different rooms of the powerhouse and the maintenance building.

All ductworks of the buildings shall be of rectangular type, calculated and designed by the supplier. Exact routing, dimensions of the duct as well as the position of the necessary equipment, blockouts etc. has to be coordinated with the civil designer.

The central air handling unit shall be provided with following components as a minimum:

- Three (3) different systems for increasing temperature, heat recovering system carried out as rotation heat exchange unit, damper register carried out as water-air heat exchanger which shall use the heating load of the mechanical equipment (out of cooling water system secondary loop), and electrical damper register

- Two (2) different system for decreasing temperature, water-air heat exchanger which is also connected to the secondary loop of the cooling water (before the supply of the mechanical equipment), and conditioning unit which shall be supplied from the outdoor unit of the VRF/VRV- system

- Filtration Unit

- Humidification and Dehumidification unit

24.5.3 Exhaust Air and high polluted Exhaust Air

Rooms with high polluted air for example sanitary rooms, kitchen, battery room, places for welding in the mechanical workshop, the generator pit, HVAC-room and others shall be equipped with an exhaust air system. If the duct is intended to evacuate CO2 gas for example then it should be accomplished with a separate “single purpose” duct that is led to a safe point outside the building.

That means that the supply air is also provided from the air handling unit but the used air is not leaded into the return air ductwork. In accordance to that, an exhaust air ductwork has to be installed in the powerhouse which has to be equipped with all necessary parts for correct operation.

24.5.4 Explosion Protection

An explosion risk exists where lead-acid batteries (particularly flooded type) are either stored or installed in a DC system and charged by a DC rectifier. The risk is primarily associated with hydrogen gas evolution, or outgassing from the battery cell and where hydrogen gas concentrations of between 4% to 75% by volume in air are potentially explosive. In order to mitigate the potential explosion risk, the room shall be adequately ventilated in accordance with the latest edition of DIN EN 50272 in order to assure that hydrogen gas by volume in air is less than 4%.

As an additional measure of protection, a hydrogen detector shall be installed at the highest point within the room, whose alarm signal shall be relayed to the central control room when the concentration of hydrogen gas is above the safe limit.

To guarantee good working conditions in the battery room there shall be also done an air velocity calculation with the needed minimum air changing rate. The higher calculated air velocity of the two calculations shall be used for the ventilation of the battery room.

To ensure, that the potentially polluted air is not shared to other rooms of the power plant the air shall be ducted directly to the exterior of the building without crossing or passing through any other rooms, if the ducting comprises of any dilatation joints they shall be inlaid into the concrete wherever possible.

24.5.5 Cooling Coils

In normal case the air handling unit is responsible for regulation of the temperature inside of the powerhouse and control building. If the units and the necessary auxiliary equipment are under operation the heat loads in some rooms is expected very high which would cause larger cooling registers of the central air handling unit. To handle this high heat loads cooling fans shall be installed at the respective rooms in the control building.

The cooling coils or fans shall be supplied with cooling medium from an outdoor unit. For heating of the rooms with low temperature, the VRV/VRF system of the power plant shall also be able to transfer the heat to these rooms.

The total system which is installed for the temperature regulation whole power plant carried out as VRF/VRV-System. The indoor units as well as the outdoor unit have to be filled with cooling agent, which shall be as biocompatible as possible.

For condensate and drainage water of the VRV cooling devices interconnection piping to connection point to the waste water system each level shall be provided.

24.5.6 Heating

Rooms needed for the operation and control of the PSPP Manara like the control rooms, rooms for the operation personnel or also sanitary rooms shall further be equipped with heating registers carried out as electrical heating coils mounted at the walls of the respective rooms.

24.5.7 Smoke Extraction and Overpressure Ventilation System

To guarantee smoke free escape route from the power cavern through the main access tunnel to the outer area, an smoke extraction unit have to be foreseen which is operating independent of the HVAC central air handling unit and shall be able to operate also in case of loss of the AC main power supply.

In case of a fire alarm inside the power cavern of Manara PSPP all the fire dampers and fire doors will be closed immediately in order to avoid smoke being spread to fire compartments not affected by the source of the incidence. Further the central air handling unit of the PSPP will be shut down.

At the same time the overpressure ventilation system of staircase 1, which is the direct connection to the escape of the access tunnel will be activated. This system shall increase the pressure by approximately 50 Pa in order to avoid smoke getting into the escape routes.

The overpressure system discharge fresh air from the outside and lead it through a duct which is equipped with ventilators into the respective staircase. The outlet of the fresh air shall be close to the ground and the fresh air shall charge the staircase with 50Pa overpressure.

The discharge of the in blown air for the staircases in the machine halls shall be through a duct pressure relief valve at the top of the respective staircase directly into the machine hall.

Similar to the escape staircase of the power cavern, all floors and rooms which have to be passed for reaching the stair case have to be supplied with a smoke extraction system. The smoke extraction system will lead the smoke of the different floors directly to the portal of the access tunnel via the smoke extraction channel and simultaneously provide the different areas with fresh air from outside area. The smoke extraction channel which shall lead the fire smoke from the power cavern to the outside shall be situated at the top of the main access tunnel.

The medical supply & emergency base (level 5) has also to be supplied with fresh air through a separate air duct. The exhaust air inside these rooms will be transferred to the smoke extraction duct via a ventilator in case of fire.

In case of fire alarm inside the main access tunnel all fire dampers will be closed immediately. The tunnel will be supplied with fresh air via the fresh air channel and a damper in the area of the power cavern. The jet fans situated in the tunnel will carry out the smoke.

In case of a fire alarm inside the control building the central air handling of the building will automatically be shut down and the overpressure ventilation system for the staircase shall be activated. The overpressure ventilation system shall guarantee an smoke free escape route through the staircase.

The position of the ducts and the ventilators (especially, large smoke extraction ventilator at the portal, main access tunnel or power cavern depending on proposed design of the contractor) has to be coordinated with the civil designer and also with the crane supplier to ensure that the operation of the crane is not restricted by the ducts.

24.5.8 Control System of the HVAC System

To guarantee an environmentally friendly control of the HVAC-system and to minimize the consumption of electrical power feeding the central air handling unit and the VRV/VRF system, all data of the different rooms shall be collected and transferred to the central air handling unit of the power plant.

The Control System of the HVAC System shall comprise following main functions:

- Regulations of the ventilators and the pressure in the ductworks
- Regulation of the supply air temperature
- Regulation of the overpressure ventilation system
- Regulation of the smoke extraction system
- Control and activating of fire dampers, fire doors and smoke release windows
- Control of the VRV/VRF system
- Monitoring of the Filters

For regulation of the room temperature, each room shall be equipped with temperature sensors and thermostats (digital panels for setting of temperature inside the room). The central air handling unit of the building is responsible for the regulation (control) of all parameters of the supply air like humidity temperature, amount of fresh air, etc.

If fire is detected from the fire protection system, the ventilation system of the power plant is automatically turned off and the extraction system as well as all other provisions like the overpressure ventilation system, etc. are activated automatically.

24.6 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component, operational tests of monitoring panels, power supplies, detectors and alarm annunciators, etc. shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

After installation, the HVAC system shall be field tested including operational tests, visual inspection of complete installations, main air flow rates, performance of heaters, coolers, performance of chiller equipment, electrical consumption, room conditions under production in all rooms, control system, insulation resistance, hydrostatical tests of whole water piping systems, etc.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement and pressure tests of the installations
- Measurements of main flow rates
- Function test of each sub-system
- Function test of overall system including interfaces to the other suppliers
- Function test of overall alarm and firefighting control system in the presence of the national fire brigade

24.7 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

24.8 Documentation

24.8.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

24.8.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3

Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Operation instruction and maintenance handbooks	Technical Report	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10

25 OIL TREATMENT PLANT

25.1 General

For the filtration and water extraction of the different oil systems, a mobile oil treatment plant shall be provided by the contractor. The oil treatment plant shall be of mobile type to use it for the equipment installed in the power cavern and control building.

Further the delivery shall also contain a mobile oil tank of sufficient capacity to store oil of one complete governing system or of turbine and generator bearings of one unit.

25.2 Scope and Design Requirements

A mobile oil processing unit of suitable rating and capacity for use with the bearings and governors of the turbines shall be provided. The processing unit shall contain all necessary equipment needed for a correct operation.

The bearing and governor oil purifying system for the two shafts of the power plant shall consist of:

- One (1) 500 l/hr mobile oil filtration and water extraction plant complete with oil evacuation pumps, vacuum pumps, degasifier, heaters, filters, connecting rubber hoses etc. and any other items required for conditioning of the oil to maintain its lubrication properties.

- One (1) mobile oil tank of sufficient capacity to store oil of one complete governing system or of turbine and generator bearings of one unit (whichever is larger), with lifting lugs for lifting the tank filled with oil.

The oil treatment plant will be capable of the following functions:

- Filtration, dehydration and degassing of oil supplied in drums before filling into the respective bearing or governing systems

- Processing of oil after long periods of use to remove solid matter, dissolved gasses, sludge, fiber, water etc.

- Complete regeneration of oil after long periods of use to restore loss factor, surface tension, saponification, acidity factor etc. to values approaching those of new oil.

- Addition of inhibitor.

25.3 Inspection and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

The oil treatment plant shall be routine tested at the workshop of the manufacturer. The Contractor is required to submit type test certificates and routine test reports of equipment for approval by the Owner before shipping the equipment.

As a minimum, the following test shall be carried out:

- Hydraulic pressure test on all components under internal pressure. The test pressure shall be 2 times the design pressure
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors, starters and other electrical and mechanical components
- Operating test of the oil treatment unit. This shall include the treatment of a minimum of 200 liter of oil. This test may also be conducted at site if the equipment is a standard product of a reputable, specialized manufacturer

The mobile oil tanks shall be tested in accordance with standards and codes of the applicable for mobile tanks containing oil.

Field tests

After installation, the system shall be field tested including operational tests, visual inspection of complete installations, main flow rates, performance of heaters, insulation resistance, hydrostatical tests of whole water piping systems, etc.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement and pressure tests of the installations
- Measurements of main flow rates
- Function test of each sub-system
- Function test of overall system including interfaces to the other suppliers

25.4 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

25.5 Documentation

25.5.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

25.5.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15
Material/Equipment specification and technical design data	Technical Report	10

BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10
Operation instruction and maintenance handbooks	Technical Report	1 month before acceptance tests

26 INDUSTRIAL AND DOMESTIC WATER SYSTEM

26.1 General

The industrial and domestic water system shall be responsible for the supply of hot and cold water, as well as waste water for the power cavern and the control building. Each building will be equipped with an independent system.

26.2 Scope of Supply

In general the scope of supply contains the design, coordination, manufacturing, storage and erection of the whole industrial and domestic water system.

The contractor guarantees a perfect operation of the equipment and is responsible for the correct installation of the whole system.

The scope of supply also comprises all needed supports, embedded parts, erection of embedded parts, wiring, etc. which is needed for the correct operation.

The calculations which are prepared for the water system shall be summarized in a calculation report. The outputs of the calculation as well as the given data of the rooms, the flow rates, water demand, etc. shall be outlined in a detailed room list to provide a good overview.

The calculations and reports shall be forwarded to the Owner for approval.

All drawings needed for the correct installation and the drawings needed for the design of the civil part of the powerhouse, including also the block-out design for openings in concrete structure, are in the scope of the contractor.

The whole equipment installed inside the power cavern, main access tunnel and control building shall be shown in detail at the drawings and have to be mentioned at the part lists of the drawings.

The routing and block-out design shall be coordinated with the civil design.

26.3 Standards

All components and sub-components of the industrial and domestic water system have to be in accordance with the latest standards and safety regulations.

26.4 Design Particulars

26.4.1 General

The industrial and domestic water system of the power cavern and control building shall supply the different sanitary, social and other rooms with drinking water and hot water. Further the water shall be collected and stored at dedicated waste water tanks.

Clean water will be supplied from the local drinking water line to the power cavern as well as to the operation building. The drinking water shall be distributed to the different consumers via a pipeline system in each building.

For the warm water supply of the different rooms like the sanitary rooms of the power cavern as well as of the control building, electrical water heaters with central water storage tanks shall be installed. Up to the Contractors design one centre storage tank or several smaller tanks will be installed.

The interface point to the public water piping will be at the boundary of switchyard area and it has to be coordinated with the local water utility.

The waste water coming from the several consumers shall be collected in pipes and stored in appropriate sewage tanks in the power cavern. At the entrance of the power cavern on level 5 a piping connection point for mobile tank car shall be installed. The sewage will be forwarded by a pumping station consisting of 2 redundant pumps. The waste water of the control building shall be collected in an outdoor tank which is buried into the ground. Level indication and general operation status shall be provided to the control system.

For condensate and drainage water of the VRV cooling devices sufficient amount of connection points for each level shall be provided.

Inside of buildings the pipelines shall be of surface mounted type. Insulated piping system shall be used for warm water supply and if the climate conditions are leading to condensate.

The pipe rooting and the exact positions of the equipment have to be coordinated with the civil detail design.

After the connection to the local drinking water supply the system contains all necessary shut off valves, one pressure control valve, check valves and an electric water heater. A draining possibility for the system has also to be provided.

The contractor guarantees a perfect operation of the equipment and is responsible for the correct installation of the whole system. The supply also comprises all needed supports, embedded parts, erection of embedded parts, wiring, etc. which is needed for the correct operation.

26.4.2 System data

The plant shall cover following capacity:

<u>Power Cavern:</u>

Water source	Local drinking water line
Heating of warm water	Electrical Water Heater
Boiler capacity	1000 l
Consumers to be supplied	4 Shower, 7 Basins, 4 Toilets

Control Building:

Water source	Local drinking water line
Heating of warm water	Electrical Water Heater
Boiler capacity	1000 l
Consumers to be supplied	4 Shower, 10 Basins, 9 Toilets

26.5 Inspections and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

Factory Tests

Routine tests of each component, operational tests of monitoring panels, power supplies, detectors and alarm annunciators, etc. shall be carried out. The Contractor is required to submit type test certificates and routine test reports for approval to the Owner before dispatch of the equipment.

Field tests

After installation, the system shall be field tested including operational tests, visual inspection of complete installations, main flow rates, performance of heaters, insulation resistance, hydrostatical tests of whole water piping systems, etc.

At least the following test shall be performed and included in the offer:

- Visual check for transportation defects and tightness
- Visual check of the erection according owner approved drawings
- Insulation measurement and pressure tests of the installations
- Measurements of main flow rates
- Function test of each sub-system
- Function test of overall system including interfaces to the other suppliers

26.6 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

26.7 Documentation

26.7.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

26.7.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Signal list, logic diagrams, terminal diagrams	Design Drawing	6
Complete connection and interconnection diagrams of all equipment	Design Drawing	10
Complete wiring diagrams	Design Drawing	10
Final schematic drawings of all auxiliary equipment	Design Drawing	10
External connections diagrams for installation	Design Drawing	15
Operation instruction and maintenance handbooks	Technical Report	15
Calculations and characteristics	Technical Report	10
Spare part list	Technical Report	15

Material/Equipment specification and technical design data	Technical Report	10
BOQ/Component lists	Design Drawing	10
Inspection and test plan	Design Drawing	12
Protection setting and alarm list	Technical Report	10
Interlocking scheme	Design Drawing	10
Cable list	Design Drawing	10

27 ELECTRICAL WORKSHOP EQUIPMENT

27.1 General

The power plant will be equipped with its own electrical workshop.

The electrical and electronic workshop shall be equipped with machine tools, equipment and tools necessary for normal maintenance and repair of the HV, MV and LV installations, DC and uninterrupted power supply systems, diesel generators, control and monitoring system, protection equipment, communication system, lighting, small power installations, auxiliary systems, generators, exciters, transformers, high voltage cable system, etc.

For the storage of the tools, testing devices and equipment a suitable number of lockers, racks, shelves and dust proof instrument boards shall be delivered and installed.

27.2 Minimum Workshop Inventory

The workshop of the powerhouse shall be equipped, at least, with the following machines and tools as a minimum:

Workbenches and Lockers

A sufficient number of workbenches, tool lockers, racks, shelves and dust proof instrument boards shall be delivered and installed, to allow executing all work in the electrical and the electronic workshops and to store the tools, the measuring and testing devices. As a minimum the following equipment shall be provided:

- One (1) Universal laboratory workbench
- Three (3) workbenches, 2.0 x 0.8 m
- One (1) workbench with test and repair facilities for hydraulic/pneumatic devices
- One (1) workbench with test and repair facilities for electronic measuring control and communication devices
- Four (4) Universal vices for bench mounting, jaws width 120 mm, jaws depth 120 mm
- Three (3) tool lockers of appropriate size
- Two (2) sheet-steel lockers of appropriate size, lockable
- Six (6) chairs suitable for workshops
- Three (3) racks of suitable dimensions
- Two (2) shelves of suitable dimensions

- Three (3) dust proof sheet-steel instrument boards of adequate dimensions, lockable doors.

Portable Tools and Equipment

- Two (2) portable electrical drilling machines with support
- One (1) portable electrical grinding machine
- Three (3) sets of small tools, screw driver, drillers, wrenches, pliers, etc.
- Four (4) sets of electronic tools (consisting of mini pliers, mini screw drivers, etc.)
- Two (2) cable-shoe pressing pliers sets, 0.5 mm^2 to 10 mm^2
- One (1) cable-shoe pressing set, 10 mm^2 to 240 mm^2
- One (1) portable fusion splicer for fibre optical cables
- Two (2) spirit levels (300 mm)
- Four (4) rechargeable lamps
- Six (6) projector lamps
- Two (2) handle operated winch
- One (1) industrial vacuum cleaner
- Two (2) ladders

Measuring

- One (1) DC insulation testers (Megger) with accuracy ±2%, range 0...500 MOhms at 10...1000 V in several steps
- One (1) AC insulation testers (Megger) with range 0...500 MOhms at 10...5000 V in several steps
- One (1) portable universal bridge with accuracy class 1, ranges: resistance 100 MOhm...10 MOhm
- One (1) portable power measuring case with one (1) double W meter, three (3) am-meters, one (1) voltmeter, one (1) phase-sequence indicator
- Three (3) multimeters for AC and DC
- Two (2) luxmeters
- Two (2) precision multiple decade resistors with rotary switches for DC and AC current

- Ten (10) sets of laboratory connection leads, suitable for all specified instruments, with vulcanized banana plugs on both ends, 1.5 mm² copper, high flexible, insulator voltage 1000 V
- Fifty (50) banana plugs
- Fifty (50) test clips fitting to banana plugs
- One (1) ring (100 m) laboratory cable 1 x 1.5 mm2 Cu
- Two (2) constant current supply units with range voltage 0 ... 60 VAC and DC current 0 ... 5 A, rated output 80 VA, for a short time (10 s) 120 VA
- Two (2) toroidal transformers with primary voltage: 230/400 V, secondary voltage: 0... 230/400, V steeples-adjustable, rated power 1000 VA
- One (1) universal digital voltmeter (high ohmic) with, accuracy class 0.1
- One (1) universal instrument high ohmic (with amplifier) for AC and DC with accuracy class 2
- Two (2) phase-sequence indicators
- One (1) portable power factor (cosϕ) measuring instrument
- One (1) portable needle frequency meter
- One (1) portable temperature measuring instrument
- One (1) portable sound level measuring instrument, microphone with linear characteristic in the range of 20 Hz to 8 kHz
- Two (2) mechanical revolution counters
- Two (2) stop-watches
- Two (2) hook-on volt-ammeters 1.2 - 60 A, 60 - 600 V
- Two (2) hook-on volt-ammeters 10 - 500 A, 250 - 500 A
- One (1) portable vibration meter
- Two (2) pocket Ohm and capacitance meters
- One (1) measuring instrument for testing of the safety measures in installations up to 1000 V (according to the regulations of IEC/VDE 0100)
- One (1) portable grounding resistance measuring device equipped with all accessories required for a proper measurement according to the relevant IEC/VDE recommendations for measuring of the grounding resistance of switchgears, of lightning system, etc. and the specific soil resistance.

- One (1) portable temperature recorder
- One (1) portable universal recorder
- One (1) stroboscope
- One (1) portable dual beam cathode ray oscilloscope for chopped and alternative operation mode
- One (1) oscillographic recorder of the portable type
- One (1) Micro ohm-meter of the portable type, suitable for measuring contact resistance of high voltage equipment

Testing Devices

- One (1) Primary current injection kit for injecting current 10 A to 200 A in steps of 10A-50A-100A-200A, suitable for 230V, 50 HZ supply.
- One (1) portable relay testing equipment for secondary injection tests to be applied on all protection relays of the plant, for checking the relay settings up to the maximum possible ranges
- One (1) AC 3 phase 24 kV testing kit for generator winding
- One (1) high voltage insulation oil testing device, freely programmable, for execution of test specifications according to IEC/VDE or other international test standards

Instrument Testing and Calibrating Devices

The test and calibrating instruments shall be mounted on trolley for easy movement to the work places. At least the following test instruments and equipment shall be included.

- One (1) 2-point recorder with pre memory
- Two (2) 2-point recorders for mA and mV
- Two (2) pressure transmitters
- Two (2) differential pressure transmitter
- One (1) 12-point recorder compensation type
- One (1) 24-point recorder compensation type
- Three (3) ammeters with standard range class 0.5
- Three (3) voltmeters with standard ranges class 0.5

- Two (2) resistor measurement instruments (bridge principle) for Pt 100 and Ni 1000
- Three (3) portable temperature instruments with sensor
- Three (3) portable hygrometers (hair principle will not be accepted)

Safety Equipment

- Six (6) sets of HV grounding device
- Four (4) sets of MV grounding device
- Four (4) sets of LV grounding device
- Two (2) high voltage indicating rods
- Two (2) medium voltage indicating rods
- Ten (10) voltage testers 500 V
- Twenty (20) pairs insulating gloves
- Five (5) pairs insulating shoes
- Ten (10) helmets
- Ten (10) goggles
- Ten (10) ear protectors
- Five (5) emergency kits
- Three (3) emergency air tanks
- Four (4) sets of reference and warning plates (white letters and red background), operating instruction plates and first aid information plates
- 200m warning tape
- Thirty (30) padlocks

Remark: At project handover the emergency kits shall be new and unused. The contents shall conform to the recommendations and guidelines provided by international health and safety standards and regulations. The emergency kits shall be separate from the ones to be available during erection and commissioning period.

Silicagel Drying Oven

One (1) drying oven for drying the replaced silicagel from the dehydrating breather of unit transformers. Heating/drying oven with an interior of stainless steel with minimum clear size of 500 mm x 500 mm x 500 mm, temperature range 60...240°C.

27.3 Inspection and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

27.4 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

27.5 Documentation

27.5.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I.

27.5.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Contents**	**Document delivery after award in months**
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3

Labelling system	Technical Report	6
Foundation drawings	Design Drawing	6
Spare part list	Technical Report	15
Inspection and test plan	Design Drawing	12
Operation instruction and maintenance handbooks	Technical Report	1 month before acceptance tests

28 MECHANICAL WORKSHOP EQUIPMENT

28.1 General

The power plant will be equipped with its own mechanical workshop.

Therefore suitable equipment such like machine tools, accessories and tools necessary for normal maintenance and small repair of the turbines, generators and auxiliary equipment installed in the power plant area shall be provided.

The maintenance and repair work to be performed include turning, drilling, grinding, welding, etc.

The scope of supply has to include all special tools, as well as special auxiliary devices including lifting devices, ropes, etc. necessary for total assembly and disassembly of all parts of the supplied works.

The supply has to include suitable hardwood or steel boards arranged for wall mounting as well as tool carts and/or tool boxes.

28.2 Minimum Workshop Inventory

The workshop of the powerhouse shall be equipped, at least, with the following machines and tools as a minimum:

- One (1) universal lathe capable of handling an item of 500 mm diameter above the lathe bed and of 1800 mm length between centers.
- One (1) eight-speed, swivel-head, sensitive pillar drill of 30 mm approximate capacity in steel of 600 MPa.
- One (1) four speed, swivel-head, sensitive bench drill of 15 mm approximate capacity, supplied complete with all necessary accessories.
- One (1) base-mounted universal drill grinder for drills and lathe tools, supplied complete with all necessary accessories.
- One (1) 300 mm floor-stand grinder supplied complete with all necessary accessories.
- One (1) hack sawing machine supplied complete with all necessary accessories.
- Hand snips (steel R = 400/500 MPa).
- One (1) electric circular saw for timber, mounted on a mobile metal chassis with tyred wheels, supplied complete with all necessary accessories.
- One (1) fully-equipped, 7-bar compressed air portable grinding machine.

- Three (3) steel section work benches of standard dimensions (1000 x 800 mm; h = about 1000 mm) with wood top and three drawers equipped with a swivel-head parallel vice of approximately 200 mm jaw opening capacity and width.

- Four (4) tool cabinets made of steel plate.

- Two (2) electrical hand drilling machine, rated power 450 W approx., double insulated

- One (1) mobile air compressor unit for workshop and maintenance

  Delivery: 30 Nm^3/h

  Nominal working pressure: 8 bar at continuous operation

- One (1) laying out set consisting of:

  1 steel table with plane surface, 1,500 x 1,500 mm

  1 steel-based marking stand, with corresponding marking tools

- Set of universal racks made of steel profiles with all necessary metal or wooden trays designed as a series of modular parts which can be used to build free-standing racks or multi-bay racking. The height of all racks shall be approx. 2.20 m to 2.30 m and the width 0.8 m. Total length approximately 4.0 m (multiple sections)

- One (1) tube vice with stand, adjustable, to suit all common pipe diameters and tubes maximum 2,000 mm long.

- Six (6) stools with 3-legged steel base; with plastic covered circular seat, adjustable in height.

- Two (2) portable electric hand grinding machines 230 V/50 Hz.

- Two (2) portable electric variable-speed drilling machines 230 V/50 Hz include two sets of carbide drills and a set of rock drill

  drilling capacity in steel 25 mm

  drilling capacity in rock 20/10 mm

- One (1) portable pneumatic worm drive nut runner suitable for up to 12 mm diameter bolts.

- One (1) spray gun suitable for low and medium viscosity fluids.

- One (1) industrial vacuum cleaner

- Three (3) hand operated pulley blocks; 2 ton

- Ten (10) compressed air hoses complete with connections suitable for instantaneous connection with compressed air tapping, length each 10 m operating pressure 8 bar

- Three (3) complete sets of small tools containing:

  industrial type files (flat, round, half-round, cornered etc.)

  scrapers (flat, bearing, triangular etc.)

  hammers (bench, rivet, nylon, lead etc.)

  chisels, punches, center punches

  angular scribing needles

  piercer awls

  screwdrivers 1 - 8 size, Philips screwdrivers 4 sizes

  wire cutter

  hacksaw with spare blades, keyhole metal saw

  plumb with 40 m string

  set machine tap drills M3 - M10

  sheet metal shear

  hexagonal key set, 2-12 mm

  shifting spanner 15 mm, 25 mm

  tape measure 30 m, tape measure 10 m

  pipe cutter 150 mm

  pipe pliers 200 mm and 350 mm

  set pipe thread cutters 10-50 mm

  scissors

  6 hollow punches for gasket rings

  combination pliers 190 mm, grip pliers 250 mm, round nose pliers 150 mm

  2 sets spiral drills 1-20 mm (one millimeter increment between each diameter), 2 sets spiral drills 20-30 mm (two millimeter increment between each drill)

set of reamers

thread cutter set M3-24 including tap drill and cutter with holder and tap wrench

set open ended spanners size 6-32 mm, size 36-72 mm

set of shifting spanners range 13 to 40 mm

set of double bent ring spanners size 6-36 mm

set of socket wrenches including complete set of ratchets size 6-32 mm

set of internal Allen key wrenches size 3-20 mm

set contact screwdriver set No. 1 to No. 4 size

universal pliers 500 V 160 mm

3 portable lamps with cable length 5 m, extension cable 20 m with plug and adapter and insulator transformer

precision screwdriver set with 4 blades

- One (1) manual hydraulic pipe bending device with standard accessories and additional bending tools
- One set of mechanical measuring instruments containing:

2 slide gauges, combined for inside and outside measurements, measuring range 0 200 mm, accuracy 1/50 mm

1 slide gauge for outside measurement, measuring range 0 - 400 mm, accuracy 1/50 mm

1 slide gauges for measuring depth, measuring range 0 - 250 mm, accuracy 1/50 mm

1 outside micrometer, measuring range 0 - 25 mm, accuracy 1/100 mm

1 outside micrometer, measuring range 25 - 50 mm, accuracy 1/100 mm

1 pair of inside micrometer heads with the necessary control rings, elongation and adjusting wrenches

2 sets of precision rules of various types and lengths

1 adjustable precision universal angle measuring equipment

1 spirit precision frame level, accuracy: 1 division - 0.05 mm per meter

2 short type and 2 long type feeler gauges with feelers of various thicknesses from 0.05 to 1.0 mm

1 ISO thread gauge M3 - M64, including tube threads

1 radius gauge concave and convex for radii 1- 7 mm

1 divider

1 outside caliper

1 inside caliper

1 straight edge, 1 m in length

2 angular scribing needle 150 mm

1 precision mechanical revolution counter

2 dial gauges, accuracy of measurements 1/100 mm

1 stopwatch accuracy of measurement 1/5 second

1 thermometer, 0 - 100°C

1 electronic vibration meter and analyzer of hand held type with pickups for measuring acceleration, velocity, amplitude of vibrations.

2 electronic gauges to measure dry film thickness of paint

- One (1) electric overhead traveling crane for mechanical workshop

  hoisting capacity 1.5 ton

  distance between centers of railway lines approximately 6 m

  rail track length approximately 10 m,

  control from suspended control bulb

- One (1) electric welding machine of the converter type with electric motor generator and stepless adjustment of current with hand wheel, capable for both SMAW and TIG welding, for a range of 35 - 500 A, with all necessary accessories for both SMAW and TIG welding, such as 2 x 10 m welding cables with electrode holders, 2 x 10 m grounding cables with clamps, Argon cylinder with 10 m length of hose, gas flow meter, protection shield, brush, welding hammer, welding gloves, etc.

- One (1) set of gas-welding equipment complete with acetylene and oxygen bottle, bottle carriage, pressure-reducing and safety valves, hoses mixing valve, 1 set of suitable nozzles, welder's glasses, etc.

- One (1) anvil, length 500 mm, width 220 mm
- One (1) welding table approx. 1,000 x 1,200 mm
- All safety equipment which is required to operate the tools and facilities listed above.

28.3 Inspection and Tests

In general the factory tests as well as the field tests have to be in accordance with the General Technical Specifications. Further the tests shall be in harmony with the standards of the client as well as the current standards and regulations.

28.4 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

28.5 Documentation

28.5.1 Information to be supplied with the Tender

According to document RFP, Annex "Technical Proposal", Volume 0 Section I.

28.5.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Contents	Document delivery after award in months
Transport way of equipment	Design Drawing	3
Arrangement and layout of equipment	Design Drawing	3
Overall schematics	Design Drawing	3
Installation drawings with connection details	Design Drawing	3
Installation drawings	Design Drawing	3
Block outs necessary for cable run and equipment	Design Drawing	3
Foundation loads	Design Drawing	3
Labelling system	Technical Report	6

Foundation drawings	Design Drawing	6
Operation instruction and maintenance handbooks	Technical Report	15
Spare part list	Technical Report	15
Inspection and test plan	Design Drawing	12

29 CRANES AND ELEVATORS

29.1 General Description

For handling of the equipment inside the different areas of the power cavern, different types of cranes will be installed for erection and maintenance of the main equipment and mechanical auxiliary systems.

In this section, all cranes and elevators of the PSPP Manara are covered.

29.2 Scope of Supply

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of following equipment:

- One (1) set of overhead-type travelling crane with a capacity of 245/15 tons (machine hall) for lifting the complete rotor, respectively stator into and out of the pit
- One (1) set of Auxiliary bridge crane with a capacity of 12.5 tons which will be installed after civil construction period
- One (1) set of Transformer bridge crane with a capacity of 5.0 tons (transformer area)
- One (1) set of monorail hoists for the draft tube gate area with an capacity of 12 tons
- One (1) set of monorail hoist for the mechanical workshop area with an capacity of 2 tons
- One (1) set of monorail hoist for the electrical workshop area with an capacity of 1 ton
- One (1) elevator for the power cavern with an capacity of 21 people of 1600 kg
- One (1) elevator for the control building with an capacity of 8 people of 630 kg

29.3 Interfaces to civil structures

The specification is outlined as functional description and therefore does not contain any technical detail design. Internal interfaces of the main components and to other parts of the Contract are summarized in the Volume 2 / Section XI.

29.4 Standards

EN 13001-1:2014 Cranes - General design – Part1: General principles and requirements

EN 13001-2:2014 Crane safety - General design – Part 2: Load actions

EN 1993-6:2010 Eurocode 3: Design of steel structures - Part 6: Crane supporting structures

29.5 Machine hall crane

29.5.1 General Description

For handling of the equipment of the cavern, one bridge crane for erection and maintenance of the main equipment and mechanical auxiliary systems shall be installed.

The crane of the machine hall shall be of indoor overhead travelling bridge crane type. The required total lifting capacity of the bridge crane installed in the powerhouse is determined by the weight of the generator stator with the upper bracket attached for lifting which will be 240 tons.

The crane which is equipped with a main and auxiliary hoist shall be designed in accordance to FEM (European Federation of Handling). The auxiliary hoist shall be designed as monorail crane type installed at one side of the bridge of the main hoist.

The installation height as well as the approach distances and the highest and lowest elevation of the crane hook have to be selected in a sufficient way and to allow all equipment to be handled to safely pass over adjacent generator/turbine units without interference.

29.5.2 Scope of Supply of the Machine Hall Crane

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of following equipment.

- One (1) overhead type travelling crane with a capacity of 245 tons. The crane shall be equipped with an monorail type auxiliary hoist with a capacity of 15 tons under the one of crane main girders.

- The runway rails equipped with all accessories needed for safe and trouble-free operation of the crane such as rail bumpers, fastenings, bolts, screws, nuts, washers, expansion joints …

- Protected bus to power the crane, which shall be done by pantograph slider. The closed busbar shall be installed at the upstream side of the power cavern. The bus shall be supplied complete with all supports, fasteners, anchors, connections, splices, connections and expansion joints; fixing materials, connection pieces to concrete structure, etc.

- One (1) complete set of conventional and special maintenance, dismantling, and erection tools, devices and equipment.
- All spare parts.
- A full electrical power system, comprising with control cabinet for the crane equipped with disconnector including interconnecting cables between this control cabinet and the power bus bar.

29.5.3 Technical data

The design of the main crane of the power cavern is determined by the weight of the generator rotor. Further the crane shall be coordinated with the design of the power cavern. The approach distances of the crane shall be as little as possible to guarantee a maximum operation space.

General performance data of the main bridge crane:

Lifting capacity of the main hoist	245 tons
Lifting capacity of the auxiliary hoist	15 tons
Rail span (center – line to center – line)	19.20 m
Length of the crane truck rails	37.00 m
Elevation of the crane truck rails (concrete Beam where rails are fixed)	28.925 m.a.s.l.
Maximum allowable deflection of the main girders	1/1000 of the track rail span
Total lift of the main hoist	32.175 m
Highest hook elevation main hoist	29.175 m.a.s.l.
Lowest hook elevation main hoist	-3.00 m.a.s.l.
Total lift of the auxiliary hoist	36.00 m
Highest hook elevation auxiliary hoist	29.00 m.a.s.l.
Lowest hook elevation auxiliary hoist	-7.00 m.a.s.l.
Power Supply	3 x 400V, 50Hz / pantograph slider (closed bus bar)

Performance data of the main hoist

Approach distance from center-line of left side rail to hook (in flow direction)	Max. 1600 mm
Approach distance from center-line of right side rail to hook (in flow direction)	Max. 2900 mm
Approach distance from lateral crane buffers to hook	Max. 2500 mm
Traveling speed of the Bridge	0-15 m/min frequency controlled
Hoisting speeds of the main hoist 0-175 tons	0-1 m/min frequency controlled
Hoisting speeds of the main hoist 0-35 tons	0-2.2 m/min frequency controlled
Trolley traveling speed	0-10 m/min
Static test load	125% of the maximum lifting capacity
Dynamic test load	110 % of the maximum lifting capacity

Performance data of the auxiliary hoist:

Approach distance from center-line of left side rail to hook (in flow direction)	Max. 750 mm
Approach distance from center-line of right side rail to hook (in flow direction)	Max. 750 mm
Approach distance from lateral crane buffers to hook	Max. 1000 mm
Hoisting speeds of the auxiliary hook	6.3/1.1 m/min (two speeds)
Trolley traveling speed	0-20 m/min
Static test load	125% of the maximum lifting capacity
Dynamic test load	110 % of the maximum lifting capacity

29.5.4 Design specific standards of the main bridge crane of the power cavern

These parts have to be designed according to the specific standards below.

Classification for steel structure	FEM M3
Classification for hoisting machinery	FEM M4
Classification for trolley traveling machinery	FEM M4
Classification for crane traveling machinery	FEM M4

FEM (European Federation of Handling)

29.5.5 Technical Requirements of the Steel Structure

29.5.5.1 Bridge

The beams of the bridge shall be welded steel box construction using high quality structural steel plates to form a sufficiently rigid set carrying the rails and buffers for the main crab. The maximum deflections of the main girders in the most unfavorable position with the maximum allowable load shall not exceed 1/1000 of the rail track span. Further other strains suffered by the structure shall not affect the equipment operation.

The bride beams of the crane shall be carried from head trucks which are articulated coupled together via a crossbeam on each side. The cross beams are also maintaining the spacing between the bridge beams of the powerhouse crane. The connection between the bridges and the head trucks shall be bolted. The main beams shall be manufactured and transported entire to the construction site, without amendments at site.

29.5.5.2 Railway of the Auxiliary Hoist

The auxiliary hoist of the machine hall bridge crane shall be a monorail crane type. So the railway of the auxiliary hoist shall be installed at one main girder of the machine hall crane.

29.5.5.3 Trolley (Crab) and Trucks

The trolley of the main hoist shall be designed to lift a maximum load of 245 tons. The crab and the trucks of the main girders shall be manufactured in structural steel and designed to permit equal load distribution for all wheels. Buffers are provided at the end of the crab.

The design of the crab shall permit road transport directly to the place of erection without amendments at side if it is possible. Further the construction of the bogies (trucks) shall be manufactured in structural steel construction forming a rigid set to transmit the load directly into the wheel axles which shall be made of high tensile alloy steel.

Screwed parts shall be thoroughly machined on contact surfaces and thermally treated before machining, to provide stress relief.

The crab shall be provided with ladders, safety hoops, checkered plated platforms with safety railings and plinths affording a convenient access to the lifting and shifting mechanisms for upkeep and repair purposes.

29.5.5.4 Monorail type Auxiliary Hoist

A monorail type auxiliary hoist shall be designed to lift a maximum load of 15 ton and shall be made of structural steel. The design of the trolley shall form a rigid steel construction and shall ensure an equal load distribution for all wheels of the trolley. Screwed parts shall be thoroughly machined on contact surfaces and thermally treated before machining, to provide stress relief.

29.5.5.5 Access Structure of the Crane

The crane shall be equipped with a gangway along all the external area of one bridge of each crane. The gangways provide easy access to the maintenance and coupling points of the crane. Furthermore access to the platform for inspection of the power bus bars and the collectors shall be provided. Gangways for the inspection and maintenance of the crab shall also be provided.

All footbridges shall give way of minimum 600 mm width and have to be equipped with a guard rail of 1 m height for safe access.

29.5.5.6 Travelling Mechanisms for the machine hall crane

There are 3 different travelling mechanisms in the machine hall crane:

- Bridge Mechanism
- Crab Mechanism
- Auxiliary Hoist Travelling Mechanism

All travelling systems shall have the same design criteria, as listed below.

The travelling systems of the power cavern bridge crane shall be designed considering the maximum and most unfavorable conditions of the load and shall comprise one or two electric motors, executed as frequency controlled squirrel cage motors. The travelling systems shall be executed with automatic breaking devices, speed reduction gearboxes as well as the transmission gear for controlling the power driven wheels.

The wheels quantity as well as the quantity of the power driven wheels shall be defined according to FEM or DIN Standards. The drive shall guarantee smooth and jerk-free motion of the trolley.

All travelling systems of the bridge crane shall be provided with a mechanical brake system, which acts automatically when the motor electric energy turns off. The brakes shall be spring activated and released by electromagnetic or electrohydraulic devices. They shall be efficient in both directions and acting in the speed reducers input shaft. The capacity of each brake has to be 150% (Main crane) / 100% (auxiliary crane) of the rated motors full load moment.

A soft stop shall be available and being activated 6 seconds before reaching the target destination.

Additional requirements for the Bridge Mechanism.

In case where the upstream and the downstream trucks (bogies) are equipped with driven wheels and controlled by separate motors, previsions have to be foreseen to avoid a skidding of the power driven wheels as a consequence of the load position.

29.5.6 Hoisting Mechanism of the main hoist

The hoist of the powerhouse bridge main crane shall be positioned at the trolley structure, contain the gearbox, coupling, brake, cable drum as well as the frequency controlled electric motor to obtain the required hoisting speeds.

Hoisting Speeds of the Main Hoist

Hoisting speed (0 … Max. tons)	0 … 1 m/min (stepless)
Hoisting speed (0 … 35 tons)	0 … 2,2 m/min (steppless)

The hoisting mechanism of the power cavern bridge main crane shall be equipped with a mechanical brake system which acts automatically when the motor electric energy turns off. The brakes shall be spring activated and released by electromagnetic or electrohydraulic devices. They shall be effective in both directions and acting in the speed reducers input shaft. The capacity of each brake has to be 200% of the rated motors full load moment.

The drums and sheaves of the crane have to be designed in accordance with the latest standards. The drums shall be designed to ensure that at least two grooves remain filled by the cable when the hook is in the lowest position and, at least, one groove remains free when the hook is in the highest position. The sheaves as well as the drums have to be equipped with roller or ball bearings.

All gears shall be in closed boxes running in oil bath and fixed to rigid supports. The gears outside of the gearboxes shall be protected via maintenance covers. For the inspection and maintenance of the gearboxes itself, oil-tight covers as well as drain plugs and oil level indicators shall be provided. The base of the gearboxes shall be machined and painted at the inside with painting resistant against lubrication oil.

The main hook for the machine hall crane shall be designed as double hook in accordance to latest DIN standard (DIN 15402). The rotary motion of the hook will be supported by axial bearings. Crosspieces of steel shall allow a pendulum movement of the hook. The pulleys shall protect the sheaves and avoid cable escaping in any operation condition.

The design and manufacturing of the wire ropes have also to be in accordance with DIN and FEM standards.

To protect the hoisting mechanism as well as the bridge itself, limiting switches shall be provided.

For save and correct operation following switches have to be foreseen as a minimum:

- Maximum and minimum lifting elevation
- Overload limiters
- Travelling limiters for the trolley
- Travelling limiters for the bridge

29.5.7 Hoisting Mechanism of the Auxiliary Hoist

Due to the long stroke of the hook, the auxiliary hoist shall be made of one standard electric wire rope hoists, of totally enclosed construction, with a brake motor system (holding capacity at least 150 % of the full load torque). Limit switches shall stop the motor when the hook reaches the highest and lowest specified positions. The single hook of the pulley block shall be of the safety type equipped with a spring-loaded latch. It shall swivel freely on grease-lubricated ball- or roller-bearings.

The construction of the electric hoist shall be in accordance with German safety standards VDE and with the design rules of FEM or DIN.

29.5.8 Travelling Track

The crane railways shall be first quality, according to the standards and mounted on the foreseen concrete beams of the powerhouse at elevation 28.925 m.a.s.l.

The supplier of the crane has to provide all fixing clamps, screws, nuts, washers, support plates, fishplates and accessories needed for the track plus 5% more in quantity for all parts of the first as well as the second stage and the railway fixing.

The railways shall also be equipped with expansion joints and joint plates which have to be located at the expansion joints of the building. The railway expansion joints have to be executed as 45° cuts and the clearances of the rail joints shall not exceed 3 mm.

The stops of bridge crane as well as the stops of the trolley have to be made of cast steel or structural steel, assembled separated of the rails and designed to withstand specific impacts. All anchors bolts, screws, nuts and washers are included in the scope of supply.

29.5.9 Current Conductors

All components of the electrical power supply which are needed for the operation of the crane have to be provided by the crane supplier. The supplier of the crane shall furnish a connection (isolator) box equipped with disconnecting switch which is installed at the wall in the machine hall.

The power busbar shall be installed at the upstream side of the power cavern and shall power the crane. All material for fixing of the pantograph slider and its correct operation shall be provided by the contractor.

For the source power to the trolley of the machine hall bridge crane flexible cables (festoon system) shall be used.

The exact location of the box has to be indicated on the drawings.

29.5.10 Motors

All motors of the cranes shall be of induction motor type with squirrel-cage rotor. These motors shall be designed according to FEM or DIN Standards, with following conditions additionally to the general technical specifications:

- direct-on line starting
- duty factor 60 % (percentage of utilization time of the motor)
- starting class: 180 (number of complete and incomplete starts per hour)
- the full rated torque must be delivered over full voltage and frequency range
- IP 44 protection

<u>Main Data of all Motors:</u>

Main current supply	400V (±10 %), 50Hz (in accordance to the grid requirements)
Noise level	max. 98dbA according to DIN 45635

29.5.11 Lighting

Each machine hall bridge crane of the power cavern shall be provided with minimum four (4) LED lamps, each 15'000 lumen, installed at the girders of the bridge.

29.5.12 Controls

For operation of the bridge crane a remote control with all possible commands and controls shall be offered. It shall allow a complete sight of all operations and easy reach to the controls for one person.

All functions of the power cavern bridge crane main hoist and the auxiliary hoist and all travelling mechanisms of the bridge crane and the auxiliary crane could be controlled by the radio control.

For the variation of the rotation speed, the motors have to be supplied with frequency converters, controlled via the radio control unit. The rotation speed has to depend on the load and the direction of the rotation speed. All movements of the travelling mechanisms as well as the movements of the hoisting have to be controlled by limiting switches.

For example: If the hook approach the highest or lowest possible positon, the lower speed mode shall automatically engage.

A radio control has to be provided and shall be installed in a portable, IP54 protected, handheld case.

The control shall contain two joysticks, one on the rights side and one on the left side of the case. For easy handling of the bridge crane there are three different modes of controlling.

- MODE1: Control of Main Hoist and Travelling Bridge Crane: Mode 1 is needed to control the main hoist, travelling of the crab as well as travelling the bridge. So the right joystick of the control shall be responsible for the main hoisting mechanism and the left joystick shall be responsible for the travelling mechanisms of the bridge and the crab.
- MODE2: Control of the Auxiliary Hoist and Travelling as well as the Bridge Travelling:
  Mode 2 is needed to control the auxiliary hoist, travelling the trolley of the auxiliary hoist as well as the travelling the bridge. So the right joystick of the control shall be responsible for the auxiliary hoisting mechanism and the left joystick shall be responsible for the travelling mechanisms of the bridge and the auxiliary hoist trolley.

29.5.13 Inspection and Tests

The scope of supply includes all needed inspections and tests of the whole equipment and it´s sub components also comprising the needed inspection and test plans and manuals for quality control of the components and subcomponents of the specified equipment.

The supplier of the given equipment shall submit the inspection and test plans (ITP) to the contractor for approval in an early stage of the project.

All needed inspections and tests shall general be in accordance with the General Technical Specification and current standards. All inspections and tests as well as the equipment which is needed for executing these tests are in scope of supply of the contractor.

29.5.13.1 Factory Tests

The factory tests of the components have to be done in accordance to the General Technical Specifications as well to the approved Inspection and Test Plans which have to be forwarded to the client. In general all tests have to be in accordance with VDE/DIN Standards, or equivalent as well as the general standards of the project owner.

Unless waived in writing by the Owner, all tests or trials shall be made in the presence of a duly authorised representative of the Owner. When the presence of the inspector is waived, certified copies of the tests made, and of the results thereof, shall be furnished as soon as possible after the tests are made.

All costs of all tests and analysis shall be borne by the Contractor and shall be included in the contract price.

29.5.13.2 Field Tests

During erection and installation at the Site the equipment shall be subject to site tests. These tests shall comprise but not be limited to the testing, checking, inspection and examination of all equipment assembled, welded and set up at the Site. It shall be understood that the period of site-testing and checking will be up to the final acceptance of all works.

Contractor shall carry out complete performance tests for each crane .All material required to make up the test loads shall be supplied by contractor. The tests shall include the following:

29.5.13.2.1 Running Test

- Operation of each control switch, contactor relay and other control device
- Test of all circuits, interlocks and sequences of operation
- Test of all protective devices
- All crane motions operate correctly
- Operating speeds

29.5.13.2.2 Static Load Test

The static load test for the crane of the power cavern shall be done with 125% of the normal load. This test shall be done for each hoist of the crane. So the testing of the machine hall bridge crane shall include:

- Static load test of the main hoist of Bridge Crane with 125% of nominal load
- Static load test of the auxiliary hoist of Bridge Crane with 125% of nominal load

29.5.13.2.3 Dynamic Load Test

The dynamic load test for the crane of the powerhouse shall be done with 110% of the maximum lifting capacity. This test shall be done for each hoist of the crane.

29.5.13.2.4 Deflection Test

The tests shall be carried out with the rated load at rest and the trolley in the central position. The deflection measurement shall be taken only after the load has been applied several times.

29.5.13.2.5 Brake Tests

All brakes shall be tested under full-load conditions, from maximum speed to rest, three times in quick succession without overheating.

29.5.13.3 Routine Tests

The contractor shall provide detailed operation and maintenance manuals which shall also contain a proposal for the routine tests of the crane, its hoists and the other sub components.

29.5.14 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

29.5.15 Documentation

29.5.15.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I, following additional particular documentation shall be provided:

- General Arrangement of equipment, Plan view, Longitudinal section, Transverse section
- Preliminary foundation loads (has to be guaranteed after commencement)

29.5.15.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Content	Document delivery after award in months
General documents		
Inspection and test plans (ITP´s)	Schedule	3
Time schedule for the manufacturing, delivery and erection of the crane and railways	Schedule	3
Outline Drawings and General Layout for:		
Power House Overhead Travelling Crane	Design Drawing	1
Load and force-related documents:		
Static calculations	Report	1
Calculation report of the whole bridge crane	Report	1
Calculation report of the railways	Report	1
Life loads and foundation loads of machine hall crane in all situations	Design Drawing	1
Construction (workshop) drawing for:		
First and second stage concrete embedded parts drawings of the railways	Design Drawing	3
Assembly drawings of the railways	Design Drawing	3
Detail design drawings of the bridge	Design Drawing	4
Detail design drawings of the crab	Design Drawing	4
Detail design drawings of the main hoist	Design Drawing	4
Detail design drawings of the auxiliary hoist	Design Drawing	4
Detail design drawings of the hooks	Design Drawing	4
Detail design assembly drawings of the machine hall bridge crane	Design Drawing	4

Detail design drawings of the bridge crane installed in the power cavern also showing the approach distances	Design Drawing	4
Power cavern overhead travelling crane	Design Drawing	4
Detail design drawing of the buffer for power cavern machine hall crane	Design Drawing	4
Electrical drawings:		
Assembly drawings of the bus bars (pantograph slider) including the power supply and disconnecting switch	Design Drawing	3
Single lines for the bridge crane and the auxiliary crane	Schematic	3
Detail design drawings of all electrical equipment (including complete schematic diagrams and wiring diagrams, interconnection diagrams, resistor connections, conduit drawings and electrical bill of material showing all material required and electrical rating of motors, switches, starters	Design Drawing	4
Manuals:		
Operation and maintenance manual(s) for the whole crane construction	Manual	9
Instruction manual for the motor	Manual	9
Instruction manual for the control system	Manual	9

29.6 Power Cavern Auxiliary Bridge Crane

29.6.1 General Description

For the construction works of the cavern a crane with an sufficient capacity will be installed inside the cavern by the contractor of the civil part of the cavern. This crane will be installed at an rigid steel construction made of I-Beams which will be directly fixed to the concrete structure of the cavern below the concrete beams of the main crane of the power cavern.

After finishing of the construction works of the civil design, the auxiliary bridge crane of the cavern contractor will be demounted.

The contractor of the power cavern auxiliary bridge crane shall deliver an indoor overhead travelling bridge crane which shall have a capacity of 12.5 tons. The crane shall be installed at the steel construction which was used by the crane for the civil contractor.

29.6.2 Scope of supply of the auxiliary bridge crane

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of following equipment.

- The design, manufacture, testing, transportation, erection, painting and commissioning of one (1) overhead type travelling crane with a capacity of 12.5 tons.
- The runway rails equipped with all accessories needed for safe and trouble-free operation of the crane such as rail bumpers, fastenings, bolts, screws, nuts, washers, expansion joints …
- Protected bus to power the crane, which shall be done by pantograph slider. The closed busbar shall be installed at the upstream side of the power cavern. The bus shall be supplied complete with all supports, fasteners, anchors, connections, splices, connections and expansion joints; fixing materials, connection pieces to concrete structure, etc.
- One (1) set of conventional and special maintenance, dismantling and erection tools, devices and equipment.
- A full electrical power system, comprising with control cabinet for the crane equipped with disconnector including interconnecting cables between this control cabinet and the power bus bar.

29.6.3 Technical data

The design of the auxiliary crane of the powerhouse is determined by the weight of the heaviest parts during civil construction works. Further the crane shall be coordinated with the design of the power cavern. The approach distances of the crane shall be as little as possible to guarantee a maximum operation space.

General performance data of the auxiliary bridge crane:

Lifting capacity of the main hoist	12.50 tons
Rail span (center – line to center – line)	17.80 m
Length of the crane truck rails	37.00 m
Elevation of the I-Beam where rail will be fixed	37.00 m.a.s.l.
Maximum allowable deflection of the main girders	1/1000 of the track rail span
Total Lift of the main hoist	34.50 m
Highest hook elevation main hoist	26.50 m.a.s.l.
Lowest hook elevation main hoist	-7.00 m.a.s.l.
Power Supply	3 x 400V, 50Hz / pantograph slider (closed bus bar)

Performance data of the hoist and approach distances:

Approach distance from center-line of upstream rail to hook	Max. 2000 mm
Approach distance from center-line of downstream rail to hook	Max. 2000 mm
Approach distance from lateral crane buffers to hook	Max. 2500 mm
Traveling speed of the Bridge	0-40 m/min frequency controlled
Hoisting speeds of the main hoist 0-12,5 tons	5/0.83 m/min frequency controlled (2-levels)
Trolley traveling speed	0-20 m/min
Static test load	125 % of the maximum lifting capacity
Dynamic test load	110 % of the maximum lifting capacity

29.6.5 Design specific standards of the auxiliary bridge crane of the power cavern

These parts have to be designed according to the specific standards below.

Classification for steel structure	FEM M4
Classification for hoisting machinery	FEM M6
Classification for trolley traveling machinery	FEM M5
Classification for crane traveling machinery	FEM M5

FEM (European Federation of Handling)

29.6.6 Bridge

The beams of the bridge shall be welded steel box construction using high quality structural steel plates to form a sufficiently rigid set carrying the rails and buffers for the crab. The maximum deflections of the main girders in the most unfavourable position with the maximum allowable load shall not exceed 1/1000 of the rail track span. Further other strains suffered by the structure shall not affect the equipment operation.

The bride beams of the crane shall be carried from head trucks which are articulated coupled together via a crossbeam on each side. The cross beams are also maintaining the spacing between the bridge beams of the power cavern crane. The connection between the bridges and the head trucks shall be bolted. The main beams shall be manufactured and transported entire to the construction site, without amendments at site.

29.6.7 Trolley (Crab) and Trucks

The trolley of the hoist shall be designed to lift a maximum load of 12.5 tons. The crab and the trucks of the main girders shall be manufactured in structural steel and designed to permit equal load distribution for all wheels. Buffers are provided at the end of the crab.

The design of the crab shall permit road transport directly to the powerhouse without amendments at side if it is possible. Further the construction of the bogies (trucks) shall be manufactured in structural steel construction forming a rigid set to transmit the load directly into the wheel axles which shall be made of high tensile alloy steel.

Screwed parts shall be thoroughly machined on contact surfaces and thermally treated before machining, to provide stress relief.

The crab shall be provided with ladders, safety hoops, checkered plated platforms with safety railings and plinths affording a convenient access to the lifting and shifting mechanisms for upkeep and repair purposes.

29.6.8 Travelling Mechanisms for the Auxiliary Bridge Crane

There are 2 different travelling mechanisms:

- Bridge Mechanism
- Crab Mechanism

All travelling systems shall have the same design criteria, as listed below.

The travelling systems of the auxiliary bridge crane shall be designed considering the maximum and most unfavorable conditions of the load and shall comprise one or two electric motors, executed as frequency controlled squirrel cage motors. The travelling systems shall be executed with automatic breaking devices, speed reduction gearboxes as well as the transmission gear for controlling the power driven wheels.

The wheels quantity as well as the quantity of the power driven wheels shall be defined according to FEM or DIN Standards. The drive shall guarantee smooth and jerk-free motion of the trolley.

All travelling systems of the bridge crane shall be provided with a mechanical brake system, which acts automatically when the motor electric energy turns off. The brakes shall be spring activated and released by electromagnetic or electrohydraulic devices. They shall be efficient in both directions and acting in the speed reducers input shaft. The capacity of each brake has to be 150% of the rated motors full load moment.

A soft stop shall be available and being activated 6 seconds before reaching the target destination.

29.6.9 Hoisting Mechanism

Due to the long stroke of the hook, the auxiliary hoist shall be made of one standard electric wire rope hoists, of totally enclosed construction, with a brake motor system (holding capacity at least 150 % of the full load torque). Limit switches shall stop the motor when the hook reaches the highest and lowest specified positions. The single hook of the pulley block shall be of the safety type equipped with a spring-loaded latch. It shall swivel freely on grease-lubricated ball- or roller-bearings.

The construction of the electric hoist shall be in accordance with German safety standards VDE and with the design rules of FEM or DIN.

29.6.10 Travelling Track

For the construction works of the cavern a crane with an sufficient capacity will be installed inside the cavern by the contractor of the civil part of the cavern. This crane will be installed at an rigid steel construction made of I-Beams which will be directly fixed to the concrete structure of the cavern below the concrete beams of the main crane of the power cavern. The needed capacity as well as the design of the I-Beam construction and the rails has to be coordinated with the civil part of the project.

After finishing of the construction works of the civil design, the auxiliary bridge crane of the cavern contractor will be demounted.

The crane railways shall be first quality, according to the standards and mounted on the foreseen I-Beam construction power cavern at elevation 32.075 m.a.s.l.

The supplier of the crane has to provide all fixing clamps, screws, nuts, washers, support plates, fishplates and accessories needed for the track plus 5% more in quantity for all parts of the first as well as the second stage and the railway fixing.

The railways shall also be equipped with expansion joints and joint plates which have to be located at the expansion joints of the building. The railway expansion joints have to be executed as 45° cuts and the clearances of the rail joints shall not exceed 3 mm.

The stops of bridge crane as well as the stops of the trolley have to be made of cast steel or structural steel, assembled separated of the rails and designed to withstand specific impacts. All anchors bolts, screws, nuts and washers are included in the scope of supply.

If the civil contractor will not use and bridge crane for the construction works inside the cavern, the supply of the I-Beam construction and rail system which shall carry the auxiliary bridge crane of the power cavern is also included in the scope of supply of the crane supplier.

29.6.11 Current Conductors

All components of the electrical power supply which are needed for the operation of the crane have to be provided by the crane supplier. The supplier of the crane shall furnish a connection (isolator) box equipped with disconnecting switch which is installed at the wall in the machine hall.

The power busbar shall be installed at the upstream side of the power cavern and shall power the crane. All material for fixing of the pantograph slider and its correct operation shall be provided by the contractor.

For the source power to the trolley as well as to the auxiliary hoist of the machine hall bridge crane flexible cables (festoon system) shall be used.

The exact location of the box has to be indicated on the drawings.

29.6.12 Motors

All motors of the cranes shall be of induction motor type with squirrel-cage rotor. These motors shall be designed according to FEM or DIN Standards, with following conditions additionally to the general technical specifications:

- direct-on line starting
- duty factor 60 % (percentage of utilization time of the motor)
- starting class: 180 (number of complete and incomplete starts per hour)
- the full rated torque must be delivered over full voltage and frequency range
- IP 44 protection

Main Data of all Motors:

Main current supply 400V (±10 %), 50Hz (Tolerances in accordance to EN 50160)

Noise level max. 98dbA according to DIN 45635

29.6.13 Lighting

Each auxiliary bridge crane of the powerhouse shall be provided with minimum two (2) LED lamps, each 5’000 lumen, installed at the girders of the bridge.

29.6.14 Controls

For operation of the bridge crane a remote control with all possible commands and controls shall be offered. It shall allow a complete sight of all operations and easy reach to the controls for one person.

All functions of the power cavern auxiliary bridge crane hoist and all travelling mechanisms of the bridge crane could be controlled by the radio control.

For the variation of the rotation speed, the motors have to be supplied with frequency converters, controlled via the radio control unit. The rotation speed has to depend on the load and the direction of the rotation speed. All movements of the travelling mechanisms as well as the movements of the hoisting have to be controlled by limiting switches.

For example: If the hook approach the highest or lowest possible positon, the lower speed mode shall automatically engage.

A radio control has to be provided and shall be installed in a portable, IP54 protected, handheld case.

The control shall contain two joysticks, one on the rights side and one on the left side of the case. For easy handling of the bridge crane there are three different modes of controlling.

29.6.15 Inspection and Tests

The scope of supply includes all needed inspections and tests of the whole equipment and it´s sub components also comprising the needed inspection and test plans and manuals for quality control of the components and subcomponents of the specified equipment.

The supplier of the given equipment shall submit the inspection and test plans (ITP) to the contractor for approval in an early stage of the project.

All needed inspections and tests shall general be in accordance with the General Technical Specification and current standards. All inspections and tests as well as the equipment which is needed for executing these tests are in scope of supply of the contractor.

29.6.15.1 Factory Tests

The factory tests of the components have to be done in accordance to the General Technical Specifications as well to the approved Inspection and Test Plans which have to be forwarded to the client. In general all tests have to be in accordance with VDE/DIN Standards, or equivalent as well as the general standards of the project owner.

Unless waived in writing by the Owner, all tests or trials shall be made in the presence of a duly authorised representative of the Owner. When the presence of the inspector is waived, certified copies of the tests made, and of the results thereof, shall be furnished as soon as possible after the tests are made.

All costs of all tests and analysis shall be borne by the Contractor and shall be included in the contract price.

29.6.15.2 Field Tests

During erection and installation at the Site the equipment shall be subject to site tests. These tests shall comprise but not be limited to the testing, checking, inspection and examination of all equipment assembled, welded and set up at the Site. It shall be understood that the period of site-testing and checking will be up to the final acceptance of all works.

Contractor shall carry out complete performance tests for each crane .All material required to make up the test loads shall be supplied by contractor. The tests shall include the following:

29.6.15.2.1 Running Test

- Operation of each control switch, contactor relay and other control device
- Test of all circuits, interlocks and sequences of operation
- Test of all protective devices
- All crane motions operate correctly
- Operating speeds

29.6.15.2.2 Static Load Test

The static load test for the auxiliary crane of the powerhouse shall be done with 125% of the maximum lifting capacity.

29.6.15.2.3 Dynamic Load Test

The dynamic load test for the auxiliary crane of the power cavern shall be done with 110% of the maximum lifting capacity. So the dynamic testing shall include:

- The motions of the hoist of the crane shall be tested with 110% of the maximum lifting capacity by 100% of the maximum travelling and hoisting speed
- All other travelling motions of each crane shall be tested with an overload of 110% of the maximum lifting capacity by 100% of the maximum travelling speed

29.6.15.2.4 Deflection Test

The tests shall be carried out with the rated load at rest and the trolley in the central position. The deflection measurement shall be taken only after the load has been applied several times.

29.6.15.2.5 Brake Tests

All brakes shall be tested under full-load conditions, from maximum speed to rest, three times in quick succession without overheating.

29.6.15.3 Routine Tests

The contractor shall provide detailed operation and maintenance manuals which shall also contain a proposal for the routine tests of the crane, its hoists and the other sub components.

29.6.16 Spare parts, tools and accessories

The requirements are defined in the General Technical Specifications.

29.6.17 Documentation

29.6.17.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I, following additional particular documentation shall be provided:

- General Arrangement of equipment, Plan view, Longitudinal section, Transverse section
- Preliminary foundation loads (has to be guaranteed after commencement)

29.6.17.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Content	Document delivery after award in months
General documents		
Inspection and test plans (ITP´s)	Schedule	3
Time schedule for the manufacturing, delivery and erection of the crane and railways	Schedule	3
Outline Drawings and General Layout for:		
Power House Auxiliary Bridge Crane	Design Drawing	1
Load and force-related documents:		
Static calculations	Report	1
Calculation report of the whole bridge crane	Report	1
Calculation report of the railways	Report	1
Life loads and foundation loads in all situations	Design Drawing	1
Construction (workshop) drawing for:		
First and second stage concrete embedded parts drawings of the railways	Design Drawing	3
Assembly drawings of the railways	Design Drawing	3
Detail design drawings of the bridge	Design Drawing	4
Detail design drawings of the crab	Design Drawing	4
Detail design drawings of the hoist	Design Drawing	4
Detail design drawings of the hooks	Design Drawing	4
Detail design assembly drawings	Design Drawing	4

Detail design drawings of the auxiliary bridge crane installed in the powerhouse also showing the approach distances	Design Drawing	4
Powerhouse overhead travelling crane	Design Drawing	4
Detail design drawing of the buffer for powerhouse machine hall crane	Design Drawing	4
Electrical drawings:		
Single lines for the bridge crane	Schematic	3
Detail design drawings of all electrical equipment (including complete schematic diagrams and wiring diagrams, interconnection diagrams, resistor connections, conduit drawings and electrical bill of material showing all material required and electrical rating of motors, switches, starters	Design Drawing	4
Manuals:		
Operation and maintenance manual(s) for the whole crane construction	Manual	9
Instruction manual for the motor	Manual	9
Instruction manual for the control system	Manual	9

29.7 Power Cavern Transformer Bridge Crane

29.7.1 General Description

The crane of the transformer area shall be of indoor overhead travelling bridge crane type. The required total lifting capacity of the bridge crane installed is determined by the weight of the different transformer parts which have to be lifted during erection as well as during maintenance works. Therefore the installed bridge crane shall have a capacity of at least 5 tons.

29.7.2 Scope of supply of the transformer bridge crane

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of following equipment.

- The design, manufacture, testing, transportation, erection, painting and commissioning of one (1) overhead type travelling crane with a capacity of 5.0 tons.

- The runway rails equipped with all accessories needed for safe and trouble-free operation of the crane such as rail bumpers, fastenings, bolts, screws, nuts, washers, expansion joints …

- Protected bus to power the crane, which shall be done by pantograph slider. The bus shall be supplied complete with all supports, fasteners, anchors, connections, splices, connections and expansion joints; fixing materials, connection pieces to concrete structure, etc.

- One (1) set of conventional and special maintenance, dismantling and erection tools, devices and equipment.

- A full electrical power system, comprising with control cabinet for the crane equipped with disconnector including interconnecting cables between this control cabinet and the power bus bar.

29.7.3 Technical data

The design of the bridge crane for the transformer area is determined by the weight of the transformer parts which have to be lifted. Further the crane shall be coordinated with the design of the power cavern and the design of the transformer. The approach distances of the crane shall be as little as possible to guarantee a maximum operation space.

General performance data of the transformer bridge crane:

Lifting capacity of the main hoist	5.0 tons
Rail span (center – line to center – line)	5.30 m
Length of the crane truck rails	12.30 m
Elevation of the crane truck rails (concrete Beam where rails are fixed)	26.825 m.a.s.l.
Maximum allowable deflection of the main girders	1/1000 of the track rail span
Total Lift of the main hoist	8.00 m
Highest hook elevation main hoist	26.375 m.a.s.l.
Lowest hook elevation main hoist	18.375 m.a.s.l.
Power Supply	3 x 400V, 50Hz / pantograph slider (closed bus bar)

Performance data of the hoist and approach distances:

Approach distance from center-line of upstream rail to hook	Max. 1000 mm
Approach distance from center-line of downstream rail to hook	Max. 1000 mm
Approach distance from lateral crane buffers to hook	Max. 1700 mm
Traveling speed of the Bridge	0-40 m/min frequency controlled
Hoisting speeds of the main hoist	0-0.2 m/min frequency controlled 0-10 m/min frequency controlled
Trolley traveling speed	0-20 m/min
Static test load	125 % of the maximum lifting capacity
Dynamic test load	110 % of the maximum lifting capacity

29.7.4 Design specific standards of the transformer bridge crane

These parts have to be designed according to the specific standards below.

Classification for steel structure FEM M5

Classification for hoisting machinery FEM M6

Classification for trolley traveling machinery FEM M6

Classification for crane traveling machinery FEM M6

FEM (European Federation of Handling)

29.7.5 Bridge

The beams of the bridge shall be welded steel box construction using high quality structural steel plates to form a sufficiently rigid set carrying the rails and buffers for the crab. The maximum deflections of the main girders in the most unfavourable position with the maximum allowable load shall not exceed 1/1000 of the rail track span. Further other strains suffered by the structure shall not affect the equipment operation.

The bride beams of the crane shall be carried from head trucks which are articulated coupled together via a crossbeam on each side.

29.7.6 Trolley (Crab) and Trucks

The trolley of the hoist shall be designed to lift a maximum load of 5.0 tons. The crab and the trucks of the main girders shall be manufactured in structural steel and designed to permit equal load distribution for all wheels. Buffers are provided at the end of the crab.

The design of the crab shall permit road transport directly to the powerhouse without amendments at side if it is possible. Further the construction of the bogies (trucks) shall be manufactured in structural steel construction forming a rigid set to transmit the load directly into the wheel axles which shall be made of high tensile alloy steel.

Screwed parts shall be thoroughly machined on contact surfaces and thermally treated before machining, to provide stress relief.

The crab shall be provided with ladders, safety hoops, checkered plated platforms with safety railings and plinths affording a convenient access to the lifting and shifting mechanisms for upkeep and repair purposes.

29.7.7 Travelling Mechanisms for the Transformer Bridge Crane

There are 2 different travelling mechanisms:

- Bridge Mechanism
- Crab Mechanism

All travelling systems shall have the same design criteria, as listed below.

The travelling systems of the transformer bridge crane shall be designed considering the maximum and most unfavorable conditions of the load and shall comprise one or two electric motors, executed as frequency controlled squirrel cage motors. The travelling systems shall be executed with automatic breaking devices, speed reduction gearboxes as well as the transmission gear for controlling the power driven wheels.

The wheels quantity as well as the quantity of the power driven wheels shall be defined according to FEM or DIN Standards. The drive shall guarantee smooth and jerk-free motion of the trolley.

All travelling systems of the bridge crane shall be provided with a mechanical brake system, which acts automatically when the motor electric energy turns off. The brakes shall be spring activated and released by electromagnetic or electrohydraulic devices. They shall be efficient in both directions and acting in the speed reducers input shaft. The capacity of each brake has to be 150% of the rated motors full load moment.

A soft stop shall be available and being activated 6 seconds before reaching the target destination.

29.7.8 Hoisting Mechanism

Due to the long stroke of the hook, the auxiliary hoist shall be made of one standard electric wire rope hoists, of totally enclosed construction, with a brake motor system (holding capacity at least 150 % of the full load torque). Limit switches shall stop the motor when the hook reaches the highest and lowest specified positions. The single hook of the pulley block shall be of the safety type equipped with a spring-loaded latch. It shall swivel freely on grease-lubricated ball- or roller-bearings.

The construction of the electric hoist shall be in accordance with German safety standards VDE and with the design rules of FEM or DIN.

29.7.9 Travelling Track

The crane railways needed for support of the transformer bridge crane shall be first quality, according to the latest standards and shall be mounted at elevation 26.825 m.a.s.l of the transformer area.

At the left side of the transformer area (in flow direction, turbine mode) the rail system could directly be mounted at the foreseen concrete beam of the power cavern. The right rail of the transformer bridge crane has to be mounted at an rigid steel construction made of I-Beams which will be directly fixed to the concrete structure.

The needed capacity as well as the design of the I-Beam construction and the rails is included in the scope of supply of the transformer bridge crane supplier.

The supplier of the crane has to provide all fixing clamps, screws, nuts, washers, support plates, fishplates and accessories needed for the track plus 5% more in quantity for all parts of the first as well as the second stage and the railway fixing.

The railways shall also be equipped with expansion joints and joint plates which have to be located at the expansion joints of the building. The railway expansion joints have to be executed as 45° cuts and the clearances of the rail joints shall not exceed 3 mm.

The stops of bridge crane as well as the stops of the trolley have to be made of cast steel or structural steel, assembled separated of the rails and designed to withstand specific impacts. All anchors bolts, screws, nuts and washers are included in the scope of supply.

29.7.10 Current Conductors

All components of the electrical power supply which are needed for the operation of the crane have to be provided by the crane supplier. The supplier of the crane shall furnish a connection (isolator) box equipped with disconnecting switch which is installed at the wall in the machine hall.

The power busbar shall be installed at the upstream side of the power cavern and shall power the crane. All material for fixing of the pantograph slider and its correct operation shall be provided by the contractor.

For the source power to the trolley as well as to the auxiliary hoist of the machine hall bridge crane flexible cables (festoon system) shall be used.

The exact location of the box has to be indicated on the drawings.

29.7.11 Motors

All motors of the cranes shall be of induction motor type with squirrel-cage rotor. These motors shall be designed according to FEM or DIN Standards, with following conditions additionally to the general technical specifications:

- direct-on line starting
- duty factor 60 % (percentage of utilization time of the motor)
- starting class: 180 (number of complete and incomplete starts per hour)
- the full rated torque must be delivered over full voltage and frequency range
- IP 44 protection

Main Data of all Motors:

Main current supply 400V (±10 %), 50Hz (Tolerances in accordance to EN 50160)

Noise level max. 98dbA according to DIN 45635

29.7.12 Lighting

Each auxiliary bridge crane of the powerhouse shall be provided with minimum two (2) LED lamps, each 5’000 lumen, installed at the girders of the bridge.

29.7.13 Controls

For operation of the transformer bridge crane a remote control with all possible commands and controls shall be offered. It shall allow a complete sight of all operations and easy reach to the controls for one person.

All functions of the transformer bridge crane hoist and all travelling mechanisms of the bridge crane could be controlled by the radio control.

For the variation of the rotation speed, the motors have to be supplied with frequency converters, controlled via the radio control unit. The rotation speed has to depend on the load and the direction of the rotation speed. All movements of the travelling mechanisms as well as the movements of the hoisting have to be controlled by limiting switches.

A radio control has to be provided and shall be installed in a portable, IP54 protected, handheld case.

The control shall contain two joysticks, one on the rights side and one on the left side of the case.

29.7.14 Inspection and Tests

The scope of supply includes all needed inspections and tests of the whole equipment and it´s sub components also comprising the needed inspection and test plans and manuals for quality control of the components and subcomponents of the specified equipment.

The supplier of the given equipment shall submit the inspection and test plans (ITP) to the contractor for approval in an early stage of the project.

All needed inspections and tests shall general be in accordance with the General Technical Specification and current standards. All inspections and tests as well as the equipment which is needed for executing these tests are in scope of supply of the contractor.

29.7.14.1 Factory Tests

The factory tests of the components have to be done in accordance to the General Technical Specifications as well to the approved Inspection and Test Plans which have to be forwarded to the client. In general all tests have to be in accordance with VDE/DIN Standards, or equivalent as well as the general standards of the project owner.

Unless waived in writing by the Owner, all tests or trials shall be made in the presence of a duly authorised representative of the Owner. When the presence of the inspector is waived, certified copies of the tests made, and of the results thereof, shall be furnished as soon as possible after the tests are made.

All costs of all tests and analysis shall be borne by the Contractor and shall be included in the contract price.

29.7.14.2 Field Tests

During erection and installation at the Site the equipment shall be subject to site tests. These tests shall comprise but not be limited to the testing, checking, inspection and examination of all equipment assembled, welded and set up at the Site. It shall be understood that the period of site-testing and checking will be up to the final acceptance of all works.

Contractor shall carry out complete performance tests for each crane .All material required to make up the test loads shall be supplied by contractor. The tests shall include the following:

29.7.14.2.1 Running Test

- Operation of each control switch, contactor relay and other control device
- Test of all circuits, interlocks and sequences of operation

- Test of all protective devices
- All crane motions operate correctly
- Operating speeds

29.7.14.2.2 Static Load Test

The static load test for the auxiliary crane of the powerhouse shall be done with 125% of the maximum lifting capacity.

29.7.14.2.3 Dynamic Load Test

The dynamic load test for the auxiliary crane of the power cavern shall be done with 110% of the maximum lifting capacity. So the dynamic testing shall include:

- The motions of the hoist of the crane shall be tested with 110% of the maximum lifting capacity by 100% of the maximum travelling and hoisting speed
- All other travelling motions of each crane shall be tested with an overload of 110% of the maximum lifting capacity by 100% of the maximum travelling speed

29.7.14.2.4 Deflection Test

The tests shall be carried out with the rated load at rest and the trolley in the central position. The deflection measurement shall be taken only after the load has been applied several times.

29.7.14.2.5 Brake Tests

All brakes shall be tested under full-load conditions, from maximum speed to rest, three times in quick succession without overheating.

29.7.14.3 Routine Tests

The contractor shall provide detailed operation and maintenance manuals which shall also contain a proposal for the routine tests of the crane, its hoists and the other sub components.

29.7.15 Spare parts, tools and accessories

The requirements are defined in the General Technical Specifications.

29.7.16 Documentation

29.7.16.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I, following additional particular documentation shall be provided:

- General Arrangement of equipment, Plan view, Longitudinal section, Transverse section
- Preliminary foundation loads (has to be guaranteed after commencement)

29.7.16.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Content**	**Document delivery after award in months**
General documents		
Inspection and test plans (ITP´s)	Schedule	3
Time schedule for the manufacturing, delivery and erection of the crane and railways	Schedule	3
Outline Drawings and General Layout for:		
Transformer Bridge Crane	Design Drawing	1
Load and force-related documents:		
Static calculations	Report	1
Calculation report of the whole bridge crane	Report	1
Calculation report of the railways	Report	1
Life loads and foundation loads in all situations	Design Drawing	1
Construction (workshop) drawing for:		
First and second stage concrete embedded parts drawings of the railways	Design Drawing	3
Assembly drawings of the railways	Design Drawing	3
Detail design drawings of the bridge	Design Drawing	4
Detail design drawings of the crab	Design Drawing	4

Detail design drawings of the hoist	Design Drawing	4
Detail design drawings of the hooks	Design Drawing	4
Detail design assembly drawings	Design Drawing	4
Transformer bridge crane	Design Drawing	4
Detail design drawing of the buffer for transformer bridge crane	Design Drawing	4
Electrical drawings:		
Single lines for the bridge crane	Schematic	3
Detail design drawings of all electrical equipment (including complete schematic diagrams and wiring diagrams, interconnection diagrams, resistor connections, conduit drawings and electrical bill of material showing all material required and electrical rating of motors, switches, starters	Design Drawing	4
Manuals:		
Operation and maintenance manual(s) for the whole crane construction	Manual	9
Instruction manual for the motor	Manual	9
Instruction manual for the control system	Manual	9

29.8 Monorail Hoist for Draft Tube Gate Area of the Power Cavern

29.8.1 General Description

On the downstream side of the pumpturbine an operationally reliable draft tube gate is foreseen in order to hydraulically isolate the pumpturbine from the low pressure waterway tunnel. For erection, maintenance and repair works of the draft tube gate the Transport Corridor which is situated at Level 3 shall be equipped with a monorail hoist with an preliminary capacity of 12 tons.

The railway of the monorail hoist shall be installed at the ceiling of the Transportation Corridor and shall enable to reach the installed draft tube gate.

The crane and its accessories shall be designed in accordance to FEM and shall further be of standard industrial type.

The installation height as well as the approach distances and the highest and lowest elevation of the crane hook have to be selected after the estimation of the final weight of the draft tube gate in a sufficient way to guarantee a maximum flexibility.

The needed max. capacity of the hoist have to be clarified with the supplier of the draft tube gate.

29.8.2 Scope of Supply

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of following equipment.

- The design, manufacture, testing, transportation, erection, painting and commissioning of one (1) overhead type, monorail electric hoist at the Transportation Corridor of Level 3 and all needed equipment
- The monorail with its support, electrical feeding and all necessary parts to make the monorail hoist complete for warranting a trouble-free and safe operation of the hoist.
- One (1) set of conventional and special maintenance, dismantling and erection tools, devices and equipment.

29.8.3 Technical Data

Total lifting capacity of the hoist	appr. 12 tons, to be coordinated with the Draft Tube Gate supplier
Length of the monorail I-beam	appr. 10 m
Location of I-beam	elev. +9.325 m.a.s.l., at the ceiling of Transportation Corridor (Level 3)
Hoisting speed	0.8/5.0 m/min
Travelling speed of the trolley	0-20 m/min
Static test load	150 % of the maximum lifting capacity
Dynamic test load	125 % of the maximum lifting capacity

29.8.4 Specific Standards for draft tube monorail crane

Classification for hoisting machinery	FEM M6
Classification for trolley traveling machinery	FEM M5

29.8.5 Design Particulars

29.8.5.1 Rail Track

For the travelling of the trolley a rail track shall be installed according to latest FEM or DIN standards. The rail track for the trolley movement shall be designed as a strong sectional beam over the entire length of the transportation corridor (Level 3). The track itself shall be mounded at anchor plates inlaid every 500mm-1500mm in the ceiling of the transport corridor. The rail shall also be provided with buffers and limiting switches.

All components needed for a complete monorail hoist rail track are in the supply of the contractor.

29.8.5.2 Electrical Hoist

The trolley shall be designed to lift a maximal necessary load for the draft tube gates and has to be made of structural steel construction forming a rigid set. The motor for travelling as well as for the hoisting mechanism of the crane shall be equipped with a brake motor system (holding 150% of the full load torque). Further limit switches shall be installed for the hoisting as well the travelling of the electrical monorail crane. The reduction gears shall be fitted with ball or roller bearings, running in an oil bath within an oil and dust proof gear box equipped with sight gauge glasses.

All components of the crane must be in accordance with latest FEM of DIN standards.

The monorail shall be controlled from the floor of the transportation corridor with a hanging push-button box containing the following controls:

- trolley travel, both directions
- lowering and lifting control of the hook at both speeds

The hook shall be made of forged annealed alloy or carbon steel. The hook shall swivel freely on grease lubricated ball or roller bearings. There shall be a latch with the hook to prevent accidental unhooking.

29.8.5.3 Motors

All motors of the cranes shall be of induction motor type with squirrel-cage rotor. These motors shall be designed according to FEM or DIN Standards, with following conditions additionally to the general technical specifications:

- direct-on line starting
- duty factor 60 % (percentage of utilization time of the motor)
- starting class: 180 (number of complete and incomplete starts per hour)

- the full rated torque must be delivered over full voltage and frequency range
- IP 44 protection

Main Data of all Motors:

Main current supply 400V (±10 %), 50Hz (Tolerances in accordance to EN 50160)

Noise level max. 98dbA according to DIN 45635

29.8.6 Inspection and Tests

The scope of supply includes all needed inspections and tests of the whole equipment and it´s sub components also comprising the needed inspection and test plans and manuals for quality control of the components and subcomponents of the specified equipment.

The supplier of the given equipment shall submit the inspection and test plans (ITP) to the contractor for approval in an early stage of the project.

All needed inspections and tests shall general be in accordance with the General Technical Specification and current standards. All inspections and tests as well as the equipment which is needed for executing these tests are in scope of supply of the contractor.

29.8.6.1 Factory Tests

The factory tests of the components have to be done in accordance to the General Technical Specifications as well to the approved Inspection and Test Plans which have to be forwarded to the client. In general all tests have to be in accordance with VDE/DIN Standards, or equivalent as well as the general standards of the project owner.

Unless waived in writing by the Owner, all tests or trials shall be made in the presence of a duly authorised representative of the Owner. When the presence of the inspector is waived, certified copies of the tests made, and of the results thereof, shall be furnished as soon as possible after the tests are made.

All costs of all tests and analysis shall be borne by the Contractor and shall be included in the contract price.

29.8.6.2 Field Tests

During erection and installation at the Site the equipment shall be subject to site tests. These tests shall comprise but not be limited to the testing, checking, inspection and examination of all equipment assembled, welded and set up at the Site. It shall be understood that the period of site-testing and checking will be up to the final acceptance of all works.

Contractor shall carry out complete performance tests for each crane .All material required to make up the test loads shall be supplied by contractor. The tests shall include the following:

29.8.6.2.1 Running Test

- Operation of each control switch, contactor relay and other control device
- Test of all circuits, interlocks and sequences of operation
- Test of all protective devices
- All crane motions operate correctly
- Operating speeds

29.8.6.2.2 Static Load Test

The static load test for the monorail crane which will be installed at the transportation corridor (at level 3) shall be done with 150% of the maximum lifting capacity.

29.8.6.2.3 Dynamic Load Test

The dynamic load test for the draft tube monorail crane of the power cavern shall be done with 125% of the maximum lifting capacity. So the dynamic testing shall include:

- The motions of the hoist of the crane shall be tested with 125% of the maximum lifting capacity by 100% of the maximum travelling and hoisting speed
- All other travelling motions of each crane shall be tested with an overload of 125% of the maximum lifting capacity by 100% of the maximum travelling speed

29.8.6.2.4 Deflection Test

The tests shall be carried out with the rated load at rest and the trolley in the central position. The deflection measurement shall be taken only after the load has been applied several times.

29.8.6.2.5 Brake Tests

All brakes shall be tested under full-load conditions, from maximum speed to rest, three times in quick succession without overheating.

29.8.6.3 Routine Tests

The contractor shall provide detailed operation and maintenance manuals which shall also contain a proposal for the routine tests of the crane, its hoists and the other sub components.

29.8.7 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

29.8.8 Documentation

29.8.8.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I, following additional particular documentation shall be provided:

- General Arrangement of equipment, Plan view, Longitudinal section, Transverse section
- Preliminary foundation loads (has to be guaranteed after commencement)

29.8.8.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Content**	**Document delivery after award in months**
General documents		
Inspection and test plans (ITP´s)	Schedule	3
Time schedule for the manufacturing, delivery and erection of the crane and railways	Schedule	3
Load and force-related documents:		
Calculation report of the whole monorail crane	Report	1
Calculation report of the railways	Report	1
Life loads and foundation loads of the monorail crane	Design Drawing	1

Construction (workshop) drawing for:		
First and second stage concrete embedded parts drawings of the railway	Design Drawing	3
Assembly drawings of the railway	Design Drawing	4
Detail design drawings of the hoist and the travelling mechanism	Design Drawing	4
Detail design assembly drawings of the monorail crane	Design Drawing	4
Detail design drawings of the monorail crane installed in the respective room also showing the approach distances	Design Drawing	4
Electrical drawings:		
Assembly drawings of the power supply	Design Drawing	3
Single lines	Schematic	3
Detail design drawings of all electrical equipment (including complete schematic diagrams and wiring diagrams, interconnection diagrams, resistor connections, conduit drawings and electrical bill of material showing all material required and electrical rating of motors, switches, starters	Design Drawing	4
Manuals:		
Operation and maintenance manual(s) for the whole crane construction	Manual	9
Instruction manual for the motor	Manual	9

29.9 Monorail Hoists of Workshop Areas

29.9.1 General Description

For easier handling of electrical and mechanical components in case of maintenance or repair works which will be done at the workshops, these rooms shall be equipped with its own lifting equipment carried out as monorail crane.

The cranes of the different areas shall be designed in accordance to FEM and shall further be of standard industrial type.

The installation height as well as the approach distances and the highest and lowest elevation of the crane hook have to be coordinated with the detail designer of the civil part of the power cavern, to guarantee maximum flexibility.

29.9.2 Scope of Supply

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of following equipment.

Installed hoisting equipment will consist of:

- 2 tons monorail electric hoists installed in the mechanical workshop which will be situated at Level 3
- 1 tons monorail electric hoists installed in the electrical workshop of the power cavern which will be situated at Level 4
- One (1) set of conventional and special maintenance, dismantling and erection tools, devices and equipment.

29.9.3 Technical Data

29.9.3.1 Data of the electrical workshop monorail hoist

Total lifting capacity of the hoist	1 ton
Length of the monorail I-beam	appr. 6,5 m
Location of I-beam	At the ceiling of electrical workshop (Level 4)
Elevation of the ceiling	17.225 m.a.s.l
Highest elevation of the hook	16.00 m.a.s.l
Lowest elevation of the hook	10.50 m.a.s.l
Hoisting speed	0.8/5.0 m/min
Travelling speed of the trolley	0-20 m/min
Static test load	150 % of the maximum lifting capacity
Dynamic test load	125 % of the maximum lifting capacity

29.9.3.3 Data of the mechanical workshop monorail hoist

Total lifting capacity of the hoist	2 ton
Length of the monorail I-beam	appr. 6.5 m
Location of I-beam	At the ceiling of mechanical workshop (Level 5)
Elevation of the ceiling	9.325 m.a.s.l
Highest elevation of the hook	8.00 m.a.s.l
Lowest elevation of the hook	4.50 m.a.s.l
Hoisting speed	0.8/5.0 m/min
Travelling speed of the trolley	0-20 m/min
Static test load	150 % of the maximum lifting capacity
Dynamic test load	125 % of the maximum lifting capacity

29.9.4 Specific Standards for draft tube monorail crane

Classification for hoisting machinery	FEM M6
Classification for trolley traveling machinery	FEM M5

29.9.5 Design Particulars

29.9.5.1 Rail Track

For the travelling of the trolley a rail track shall be installed according to latest FEM or DIN standards. The rail track for the trolley movement shall be designed as a strong sectional beam over the entire length of both workshops. The track itself shall be mounted at anchor plates inlaid every 500mm-1500mm in the ceiling of the workshops. The rail shall also be provided with buffers and limiting switches.

All components needed for a complete monorail hoist rail track are in the supply of the contractor.

29.9.5.2 Electrical Hoist

The trolley of the monorail crane which will be installed at the ceiling of the mechanical workshop shall be designed to lift a maximal load of 2 tons.

The trolleys of the electrical workshop monorail crane shall be designed to lift a maximal load of 1 ton.

Both trolleys have to be made of structural steel construction forming a rigid set. The motor for travelling as well as for the hoisting mechanism of the crane shall be equipped with a brake motor system (holding 150% of the full load torque). Further limit switches shall be installed for the hoisting as well the travelling of the electrical monorail crane. The reduction gears shall be fitted with ball or roller bearings, running in an oil bath within an oil and dust proof gear box equipped with sight gauge glasses.

All components of the cranes must be in accordance with latest FEM of DIN standards.

The monorail cranes shall be controlled from the floor of the workshops with a hanging push-button box containing the following controls:

- trolley travel, both directions
- lowering and lifting control of the hook at both speeds

The hook shall be made of forged annealed alloy or carbon steel. The hook shall swivel freely on grease lubricated ball or roller bearings. There shall be a latch with the hook to prevent accidental unhooking.

29.9.5.3 Motors

All motors of the cranes shall be of induction motor type with squirrel-cage rotor. These motors shall be designed according to FEM or DIN Standards, with following conditions additionally to the general technical specifications:

- direct-on line starting
- duty factor 60 % (percentage of utilization time of the motor)
- starting class: 180 (number of complete and incomplete starts per hour)
- the full rated torque must be delivered over full voltage and frequency range
- IP 44 protection

<u>Main Data of all Motors:</u>

Main current supply 400V (±10 %), 50Hz (Tolerances in accordance to EN 50160)

Noise level max. 98dbA according to DIN 45635

29.9.6 Inspection and Tests

The scope of supply includes all needed inspections and tests of the whole equipment and it´s sub components also comprising the needed inspection and test plans and manuals for quality control of the components and subcomponents of the specified equipment.

The supplier of the given equipment shall submit the inspection and test plans (ITP) to the contractor for approval in an early stage of the project.

All needed inspections and tests shall general be in accordance with the General Technical Specification and current standards. All inspections and tests as well as the equipment which is needed for executing these tests are in scope of supply of the contractor.

29.9.6.1 Factory Tests

The factory tests of the components have to be done in accordance to the General Technical Specifications as well to the approved Inspection and Test Plans which have to be forwarded to the client. In general all tests have to be in accordance with VDE/DIN Standards, or equivalent as well as the general standards of the project owner.

Unless waived in writing by the Owner, all tests or trials shall be made in the presence of a duly authorised representative of the Owner. When the presence of the inspector is waived, certified copies of the tests made, and of the results thereof, shall be furnished as soon as possible after the tests are made.

All costs of all tests and analysis shall be borne by the Contractor and shall be included in the contract price.

29.9.6.2 Field Tests

During erection and installation at the Site the equipment shall be subject to site tests. These tests shall comprise but not be limited to the testing, checking, inspection and examination of all equipment assembled, welded and set up at the Site. It shall be understood that the period of site-testing and checking will be up to the final acceptance of all works.

Contractor shall carry out complete performance tests for each crane .All material required to make up the test loads shall be supplied by contractor. The tests shall include the following:

29.9.6.2.1 Running Test

- Operation of each control switch, contactor relay and other control device
- Test of all circuits, interlocks and sequences of operation
- Test of all protective devices
- All crane motions operate correctly
- Operating speeds

29.9.6.2.2 Static Load Test

The static load test for the cranes of the powerhouse shall be done with 150% of the maximum lifting capacity.

29.9.6.2.3 Dynamic Load Test

The dynamic load test for the cranes of the powerhouse shall be done with 125% of the maximum lifting capacity. So the dynamic testing shall include:

- The motions of the hoist of the crane shall be tested with 125% of the maximum lifting capacity by 100% of the maximum travelling and hoisting speed
- All other travelling motions of each crane shall be tested with an overload of 125% of the maximum lifting capacity by 100% of the maximum travelling speed

29.9.6.2.4 Deflection Test

The tests shall be carried out with the rated load at rest and the trolley in the central position. The deflection measurement shall be taken only after the load has been applied several times.

29.9.6.2.5 Brake Tests

All brakes shall be tested under full-load conditions, from maximum speed to rest, three times in quick succession without overheating.

29.9.6.3 Routine Tests

The contractor shall provide detailed operation and maintenance manuals which shall also contain a proposal for the routine tests of the crane, its hoists and the other sub components.

29.9.7 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

29.9.8 Documentation

29.9.8.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I, following additional particular documentation shall be provided:

- General Arrangement of equipment, Plan view, Longitudinal section, Transverse section
- Preliminary foundation loads (has to be guaranteed after commencement)

29.9.8.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	Content	Document delivery after award in months
General documents		
Inspection and test plans (ITP´s)	Schedule	3
Time schedule for the manufacturing, delivery and erection of the cranes and railways	Schedule	3
Load and force-related documents:		
Calculation report of the whole monorail cranes	Report	1
Calculation report of the railways	Report	1
Life loads and foundation loads of the monorail cranes	Design Drawing	1
Construction (workshop) drawing for:		
First and second stage concrete embedded parts drawings of the railway	Design Drawing	3
Assembly drawings of the railway	Design Drawing	4
Detail design drawings of the hoist and the travelling mechanism	Design Drawing	4
Detail design assembly drawings of the monorail crane	Design Drawing	4
Detail design drawings of the monorail cranes installed in the respective room also showing the approach distances	Design Drawing	4
Electrical drawings:		
Assembly drawings of the power supply	Design Drawing	3
Single lines	Schematic	3
Detail design drawings of all electrical equipment (including complete schematic diagrams and wiring diagrams, interconnection	Design Drawing	4

diagrams, resistor connections, conduit drawings and electrical bill of material showing all material required and electrical rating of motors, switches, starters		
Manuals:		
Operation and maintenance manual(s) for the whole cranes construction	Manual	9
Instruction manual for the motor	Manual	9

29.10 <u>Elevators</u>

29.10.1 General Description

For easier transport of small equipment as well as the transportation of people, the power cavern and the control building shall be equipped with adequate elevators.

The power cavern shall be equipped with an elevator for transport of persons and material between the machine hall floor which is located at elevation 18.675 m a.s.l. and the main inlet valve floor 1.45 m a.s.l The location of the elevator shaft is shown on the attached power cavern drawings.

The control building shall be equipped with an elevator for transport of persons and material between the ground floor elevation 78.50 m a.s.l. and top floor 85.98 m a.s.l The location of the elevator shaft is shown on the attached control building drawings.

29.10.2 Scope of Supply

The scope of supply contains the design, manufacturing, preassembly, tests, transportation and erection supervision of all materials, components and accessories, commissioning and technical documents, necessary for correct operation of both elevators which are mainly containing of following equipment:

- Hoisting machine with provision for hand operation
- Landing doors and thresholds
- Car, counterweight, safety gear and buffers
- Suspension, overspeed governor and final limit switches
- Guides
- Electric installations, control and appliances
- First lubricant fill plus 10% reserve
- Special tools

- Spare parts.

29.10.3 Standards

The elevator and all its components shall be designed in accordance to the latest standards and regulations. The supplier of the elevator is responsible to deliver a state of the art system which is also in harmony with the safety regulations of the power cavern as well as the control building itself. Used standards and safety regulations have to be mentioned in the documentation of the elevator and have also to be shown at the drawings of the different systems and components.

29.10.4 Technical Data

Elevator data in the power cavern	
Type of elevator	Personnel and freight
Rated capacity	1600 kg / 21 persons
Shaft dimensions (width x depth)	2.45 m x 3.00 m
Minimum car inside dimensions (width x depth x height)	1.40 m x 2.40 m x 2.30 m
Rated speed	1.00 m/s
Travel	20.125 m
Stops	4
At Elevations:	
Machine hall	18.675 m a.s.l.
Generator floor	10.625 m a.s.l.
Turbine floor	4.50 m a.s.l.
Valve floor	1.45 m a.s.l.
Machinery room location	Top
Power supply	400/230 V, 50 Hz
Elevator data in control building	
Type of elevator	Personnel and freight
Rated capacity	630 kg / 8 persons
Shaft dimensions (width x depth)	1.82 m x 2.50 m
Minimum car inside dimensions (width x depth x height)	1.10 m x 1.40 m x 2.20 m
Rated speed	1.00 m/s
Travel	11.65 m
Stops	3
At Elevations:	85.98 m a.s.l.

	82.24 m a.s.l.
	78.50 m a.s.l.
Machinery room location	Top
Power supply	400/230 V, 50 Hz

29.10.5 Cabin, Equipment of Elevator Shaft and Driving Machinery

The elevators will be used for the transportation of smaller loads and also persons.

The cabin of the elevator shall be designed as rigid steel construction equipped with the stopping and sliding device needed for driving of the cabin. The inside area of the cabin shall be made of stainless steel.

The elevator shall be driven by an electric hoisting machine. The drive motor shall be designed to operate on a duty cycle of 240 starts per hour. The doors of the elevator as well as the landing doors (doors at each floor) shall be of automatic sliding type and have to be designed in accordance to DIN EN 81-1/2 or if available in accordance to local standards.

The elevator shaft will be supplied with air from the HVAC system of the powerhouse. The roof of the cabin shall be provided with an emergency and maintenance doo with a size of 600 x 600mm. Further the maintenance and emergency door shall be provided with a telescope ladder which allows access from the car bottom to the roof.

29.10.6 Current Conductors

All components of the electrical power supply which are needed for the operation of the elevator have to be provided by the elevator supplier. The supplier for the elevator shall furnish a connection box equipped with disconnecting switch which is installed on the wall near the driving machinery.

For the equipment of the elevator a power supply with 3 x 400 V and 50 Hz (Tolerances in accordance to EN 50160) has to be provided.

The power supply shall further lead from the lockable disconnecting switch to the driving machinery of each elevator which is installed at the top of the elevator shaft.

The exact location of the box which is equipped with the disconnecting switch and the exact rooting of the cables including the dimensions have to be indicated on the drawings.

29.10.7 Controls

For the control of the elevator, the cabin of the elevator shall be equipped with a control panel. This control panel shall be equipped with all possible functions of the elevator and shall enable the user an comfortable use of the elevator and its position have to be taken in a sufficient way for easy reaching of all control buttons. The buttons shall contain pictograms for the desired function.

In general the control panel of the cabin shall have following functions:

Numbers of the floors:

- Open Door
- Close Door
- Emergency Stop
- Emergency Alarm

For calling of the elevator, each floor shall be equipped with its own control panel with two buttons. The lower button of the control panel shall call the elevator to move downwards and the upper button of the control panel for calling the elevator to move upwards (indicated by arrows). These local control panels of each floor shall be installed near the elevator doors in a sufficient height and have to be flush with the wall by the elevator shaft.

For maintenance and repair works, the elevator shall also be equipped with a control panel at the roof of the cabin. This control panel shall allow to control all movements of the elevator.

29.10.8 Motors

All motors of the elevators shall be of induction motor type with squirrel-cage rotor. These motors shall be designed according to FEM or DIN Standards, with following conditions additionally to the general technical specifications:

- direct-on line starting
- duty factor 60 % (percentage of utilization time of the motor)
- starting class: 240 (number of complete and incomplete starts per hour)
- the full rated torque must be delivered over full voltage and frequency range
- IP 44 protection

<u>Main Data of all Motors:</u>

Main current supply 400V (±10 %), 50Hz (Tolerances in accordance to EN 50160)

Insulation class F according IEC (utilization B)

International Protection code IP 44 for motors

Squirrel cage motor	Direct connection IA / IN ≤ 6
Noise level	max. 98dbA according to DIN 45635
Thermal protection	PTC Thermistor

29.10.9 Lighting

The cabin of the elevator shall be equipped with LED lighting system which shall be in accordance to current standards. Further the scope of supply also comprised LED lamps inside the elevator shaft of the power cavern as well as of the control building and the area of the driving machinery of the elevator which will be used for maintenance and repair works of the elevator. The light for maintenance works shall be turned on by opening the maintenance door of the driving cabin and/or the control panel for maintenance works. The whole lighting shall be carried out as LED system.

29.10.10 Inspection and Tests

The scope of supply includes all needed inspections and tests of the whole equipment and it´s sub components also comprising the needed inspection and test plans and manuals for quality control of the components and subcomponents of the specified equipment.

The supplier of the given equipment shall submit the inspection and test plans (ITP) to the contractor for approval in an early stage of the project.

All needed inspections and tests shall general be in accordance with the General Technical Specification and current standards. All inspections and tests as well as the equipment which is needed for executing these tests are in scope of supply of the contractor.

29.10.10.1 Factory Tests

The factory tests of the components have to be done in accordance to the General Technical Specifications as well to the approved Inspection and Test Plans which have to be forwarded to the client. In general all tests have to be in accordance with VDE/DIN Standards, or equivalent as well as the general standards of the project owner.

Unless waived in writing by the Owner, all tests or trials shall be made in the presence of a duly authorised representative of the Owner. When the presence of the inspector is waived, certified copies of the tests made, and of the results thereof, shall be furnished as soon as possible after the tests are made.

All costs of all tests and analysis shall be borne by the Contractor and shall be included in the contract price.

29.10.10.2 Field Tests

During erection and installation at the Site the equipment shall be subject to site tests. These tests shall comprise but not be limited to the testing, checking, inspection and examination of all equipment assembled, welded and set up at the Site. It shall be understood that the period of site-testing and checking will be up to the final acceptance of all works.

Contractor shall carry out complete performance tests for each elevator .All material required to make up the test loads shall be supplied by contractor. The tests shall include the following:

29.10.10.3 Routine Tests

The contractor shall provide detailed operation and maintenance manuals which shall also contain a proposal for the routine tests of the elevator, its hoists and the other sub components.

29.10.11 Spare parts, tools and consumables

The requirements are defined in the General Technical Specifications.

29.10.12 Documentation

29.10.12.1 Information to be supplied with the Tender

According to document RFP, Annex “Technical Proposal”, Volume 0 Section I, following additional particular documentation shall be provided:

- General Arrangement of equipment, Plan view, Longitudinal section, Transverse section
- Preliminary foundation loads (has to be guaranteed after commencement)

29.10.12.2 Drawings and Information to be submitted after Commencement Date

The following documents shall be supplied individually or as a whole for equipment/installations:

Designation	**Content**	**Document delivery after award in months**
General documents		
Inspection and test plans (ITP´s)	Schedule	3

Time schedule for the manufacturing, delivery and erection of the elevator and the equipment which will be installed inside and outside of the elevator shaft	Schedule	3
Load and force-related documents:		
Calculation report of the elevator	Report	1
Calculation report of the railways for sliding and the driving machinery	Report	1
Detail design drawings showing the life loads and foundation loads of the elevator	Design Drawing	1
Construction (workshop) drawing for:		
First and second stage concrete embedded parts drawings/needed structure inside shaft	Design Drawing	3
Assembly drawings of the sliding rails	Design Drawing	3
Detail design drawings of the cabin	Design Drawing	4
Detail design drawings of the lifting / driving machinery	Design Drawing	4
Detail design assembly drawings of the whole elevator	Design Drawing	4
Detail design drawings of the elevator installed in the power cavern and inside the operation building also showing the defined stops	Design Drawing	4
Electrical drawings:		
Single lines for the elevator and its driving machinery	Schematic	3
Assembly drawings of the power supply, the disconnecting switch as well the control panels which are installed outside the shaft and the connection to the low voltage distribution	Design Drawing	3
Detail design drawings of all electrical equipment (including complete schematic diagrams and wiring diagrams, interconnection diagrams, resistor connections, conduit drawings and electrical bill of material showing all material required and electrical rating of motors, switches, starters	Design Drawing	4

Manuals:		
Operation and maintenance manual(s) for the whole elevator construction	Manual	9